

MEGAPALEONTOLOGY OF THE EOCENE LLAJAS FORMATION, SIMI VALLEY, CALIFORNIA

Richard L. Squires¹

ABSTRACT. The paleontology and stratigraphic distribution of the megafossils in the late early through early middle Eocene age Llajas Formation, Simi Valley, Los Angeles and Ventura Counties, southern California, are described in detail. One hundred and seven species and subspecies, representing 88 identifiable genera, are recorded for 132 localities. Twenty-six of these species are previously unreported from the Llajas Formation.

Illustrations, synonymies, primary type material information, West Coast molluscan stage ranges, geographic distributions, local occurrences, and remarks are provided for the taxa, which include one large foraminifer, two corals, one brachiopod, one annelid, two scaphopods, 65 gastropods, 29 bivalves, one nautiloid, one sepiid, one brachyuran, one spatangoid, and two sharks. The sepiid can be identified only to the family level. A new species of *Cerithiopsis* and a new species of *Ancistrolepis*? are named. *Crassatella uvasana* and *C. u. semidentata* are shown to be identical.

Most of the megafossils occur in channel-fill deposits in shallow-marine strata but have undergone minimal postmortem transport. The Llajas megafauna lived in warm waters less than 80 m depth.

Mollusks indicative of the lower of the two faunal zones of the West Coast provincial molluscan "Capay Stage" (lower Eocene) are present in the lowermost fossil-bearing beds of the Llajas Formation. The remaining fossil-bearing part of the Llajas contains mollusks indicative of the "Domengine Stage" (upper lower through lower middle Eocene). Age refinement of the Llajas extends the molluscan stage ranges of several molluscan species. The Llajas megafauna is similar to those in late early-early middle Eocene age formations from San Diego, California through southwestern Oregon. These megafaunas were in the same faunal province that extended, at least, from southern California into Washington. Most of the genera were already present on the West Coast by Llajas time and several species were carry-overs from earlier times. A few genera were early Eocene immigrants from the Caribbean and Old World Tethyan regions, and some were early middle Eocene immigrants from the same regions. Several genera originated on the West Coast during the early middle Eocene.

INTRODUCTION

Since the early 1900's, paleontologists have collected megafossils from the late early through early middle age Eocene Llajas Formation in the Simi Valley area, Los Angeles and

Ventura Counties, southern California. The fossils are predominantly mollusks and nearly every paleontological museum on the West Coast has a representative collection. To date, however, there has been no comprehensive taxonomic and stratigraphic analysis of the Llajas megafauna. Researchers, therefore, have been hindered in performing detailed comparative studies on the taxonomy, biogeography, and time-correlation of the Llajas megafossils. The objectives of this paper are 1) to tabulate the species and show their distribution within the formation, 2) to provide synonymies and illustrations of the species, 3) to provide taxonomic refinements of certain known taxa and describe two new gastropods, 4) to interpret the paleoenvironment and biogeography of the megafauna, 5) to refine the age assignment and correlation of the Llajas Formation, and 6) to refine the West Coast molluscan stage ranges of the taxa.

The Llajas Formation crops out in the southwestern Santa Susana Mountains and along the south side of Simi Valley (Fig. 1). It disconformably overlies the late Paleocene through earliest Eocene age marine Santa Susana Formation and, except where local faults occur, is unconformably overlain by the early late Eocene through Oligocene age nonmarine Sespe Formation (Figs. 2 and 3).

Outcrops of the Llajas Formation are typically extensively covered. Best exposures are at the 545-m-thick type section in the southwestern Santa Susana Mountains (Fig. 1). In 1981 and 1983b, I reported that the Llajas Formation in the southwestern Santa Susana Mountains consists mostly of a transgressive (retrogradational) sequence of facies that grades vertically from coastal alluvial fan, to shallow marine, to outer shelf and slope with incised channels. The outer shelf and slope facies was subsequently covered by regressive (progradational) shallow-marine facies. The regressive sequence is

1. Department of Geological Sciences, California State University, Northridge, California 91330, and Research Associate, Invertebrate Paleontology, Natural History Museum of Los Angeles County.

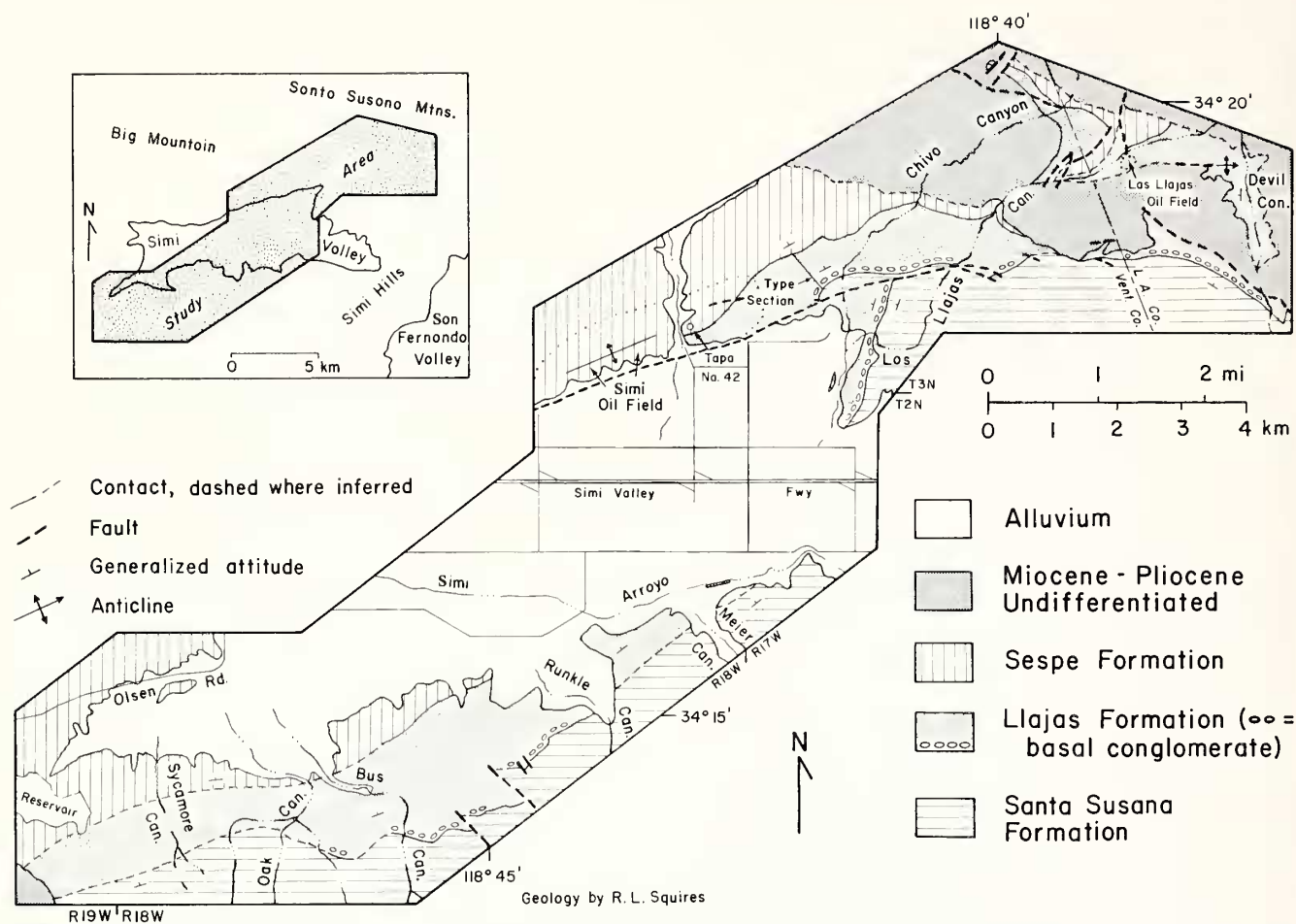


Figure 1. Geologic map showing outcrops of the Lajas Formation in the Simi Valley area, southern California (after Squires, 1983b).

incomplete due to erosional truncation by the Sespe Formation (Fig. 2).

HISTORICAL REVIEW

In the last 70 years, starting with Waring (1914), there have been many investigations dealing with the megafossils of the Lajas Formation. These previous studies have included partial faunal lists (Waring, 1917; Clark, 1926; Hanna, 1927; McMasters, 1932; Cushman and McMasters, 1936; Turner, 1938; Vokes, 1939; Lewis, 1940; Seiden, 1972), descriptions of new taxa (Waring, 1914, 1917; Schenck, 1926; Stewart, 1927, 1930; Clark, 1934, 1942; Merriam and Turner, 1937; Vokes, 1937, 1939; Bentson, 1940; Merriam, 1941; Hertlein and Grant, 1944; Sutherland, 1966; Squires, 1983a), and taxonomic refinements or miscellaneous comments on known species. In this last category, the most notable papers are those of Schenck (1931), Gardner and Bowles (1934), Clark and Vokes (1936), Turner (1938), Vokes (1935, 1939), Merriam (1941), Hanna and Hertlein (1943), Verastegui (1953), Marincovich (1977), Givens (1979), Squires (1979), and Saul (1983).

As the name "Lajas Formation" was not formalized until 1936 by Cushman and McMasters, earlier workers referred to such strata by various names (Fig. 4). Clark and Vokes (1936), Turner (1938), and Vokes (1939) used the terms "Lower Lajas" and "Upper Lajas" but did not define them.

Various aspects of the microfossils of the Lajas Formation have been reported on by McMasters (1932), Cushman and McMasters (1936), Laiming (1940a, 1940b, 1943), Mallory (1959), Schymiczek and Squires (1981), Schymiczek (1983a, 1983b), and Filewicz and Hill (1983).

MEGAFOSSILS

One hundred and seven taxa, more than 90 percent of which are mollusks, were identified from the Lajas Formation. Taxa identified to species and subspecies include 64 gastropods, 28 bivalves, two scaphopods, two solitary corals, and one species each of large foraminifer, brachiopod, annelid, nautiloid, brachyuran, and spatangoid. One gastropod, one bivalve, and two sharks are identified only to genus. A spirulimorph sepiid could only be identified to the family level. All of these taxa are illustrated in Figures 5 through 13. Other

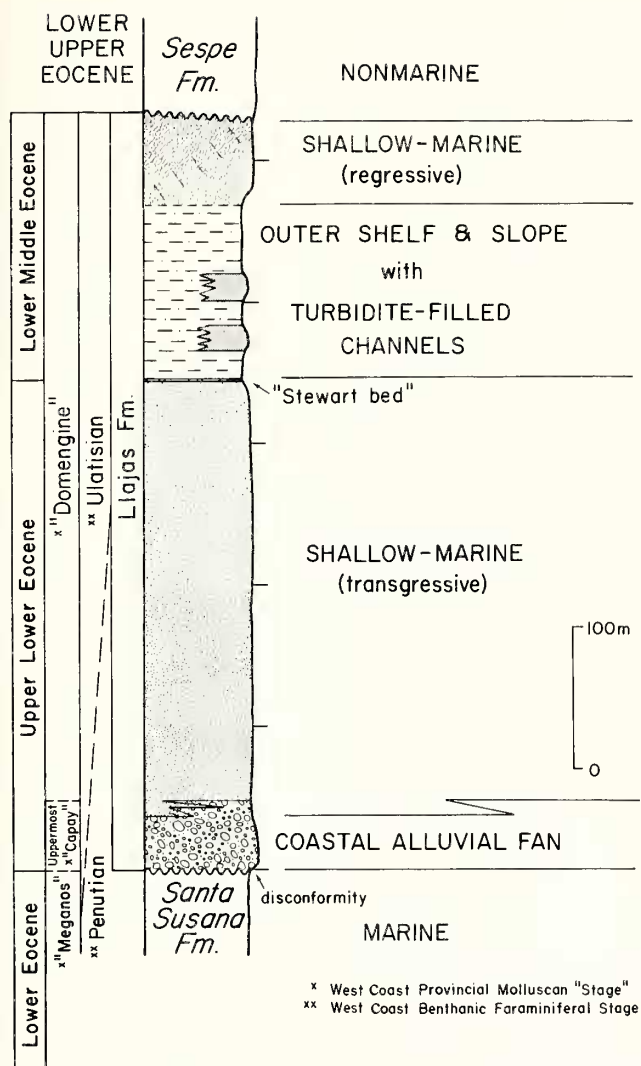


Figure 2. Stratigraphic column of the Llajas Formation, showing depositional environments based on Squires (1981, 1983b).

taxa, too poorly preserved for even generic determination, include a bryozoan, two brachiopods, calcareous worm tubes, two gastropods, a nautiloid, a myliobatoid, and scattered *Teredo*-bored wood fragments.

The identifications of Llajas species and subspecies studied in this report are based on published figures and descriptions and selected comparisons with type specimens and non-type specimens on deposit at 1) Department of Earth and Space Sciences, University of California at Los Angeles, 2) University of California, Museum of Paleontology, Berkeley, 3) Natural History Museum of Los Angeles County, and 4) California State University, Northridge.

Megafossils were collected at 121 localities in the southwestern Santa Susana Mountains and 11 localities along the south side of the Simi Valley. All of the localities are described in the "Localities" section, and the relative strati-

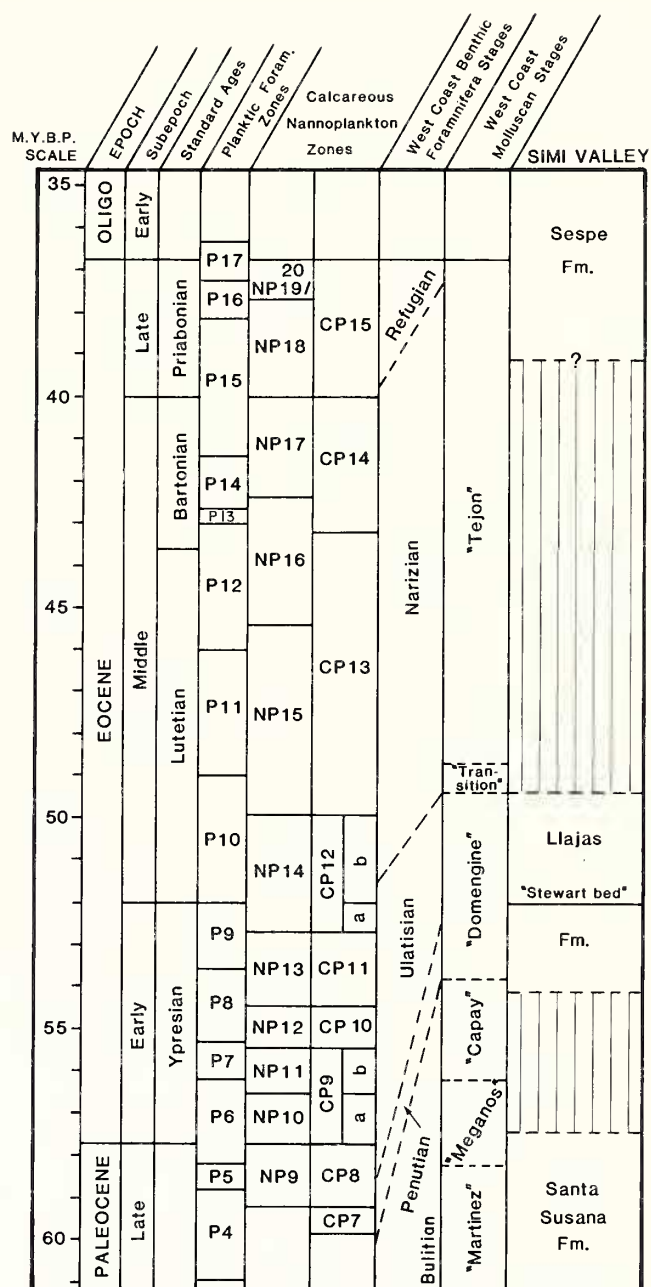


Figure 3. Correlation of the Llajas Formation with Eocene West Coast molluscan stages (after Saul, 1983); millions of years before present (M.Y.B.P.) scale, epochs, subepochs, standard ages, planktic foraminifera zones, and calcareous nannoplankton zones (all after Berggren, Kent, and Flynn, in press); and West Coast benthic foraminifera stages (after Poore, 1980).

graphic position of each one is shown in Figures 14 through 19.

Species and subspecies with holotype localities in the Llajas Formation are listed in Table 1. Species not previously reported from the Llajas Formation are listed in Table 2.

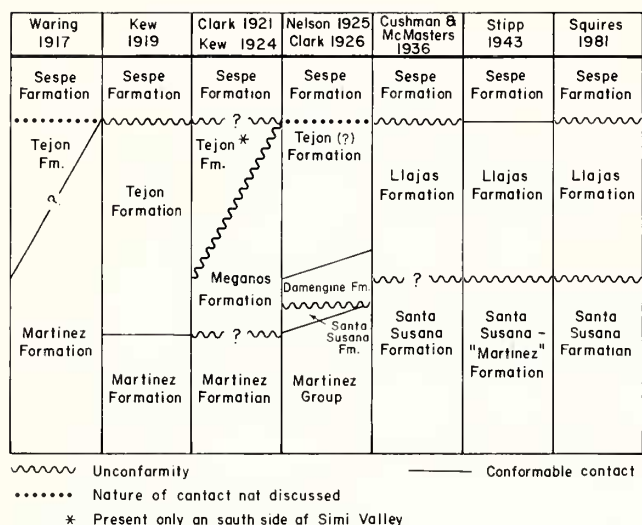


Figure 4. Comparative concepts of Paleogene stratigraphy in the Simi Valley area (after Squires, 1983b).

Some megafossil species previously reported (Waring, 1914, 1917; Clark, 1921:158–159, 1926:114–116; Clark, 1942; Kew, 1924:25, 29; Hanna, 1927:260; Vokes, 1935, 1939:23–26, 30–31; Clark and Vokes, 1936; Turner, 1938:33–37; Benton, 1940; Ingram, 1940) from the Llajas Formation (or generally equivalent strata) were not found during the present study. There are serious problems in trying to substantiate the records of these species because 1) locality information is either lacking or vague, and/or 2) previously used formation names (i.e., Meganos and Domengine) are not the exact equivalents of the Llajas Formation (Fig. 3). In addition, because these species names usually have only been listed, without illustration or reference to catalogued museum specimens, there is no way to verify the identifications. Some of these so-called “Llajas” species can be shown to be from the underlying late Paleocene through earliest Eocene age Santa Susana Formation. Based on analysis of Zinsmeister’s (1974, 1983a) work on the megafauna of the Santa Susana Formation, the following species are from this unit: *Cucullaria morani* [= *Cucullaea*], mentioned by Waring (1914, 1917); *Polinices hornii*, *Mesalia martinezensis* [= *Turritella*], *Turritella infragramulata*, and *Septifer elegans*, mentioned by Waring (1917). Clark (1942) reported that the type locality of *Chedevillea stewarti* and *Tibia* (*Eotibia*) *llajasensis* is in the lower portion of the Llajas Formation. According to Keen and Benton (1944:143), this locality (University of California, Museum of Paleontology, Berkeley, locality 7015) plots within Paleocene strata as mapped by Nelson (1925).

The marine strata of the Llajas Formation have been thoroughly bioturbated, but the only identifiable trace fossils are *Ophiomorpha*, *Thalassinoides*, and *Chondrites*?. The first two ichnogenera are fairly common in the shallow-marine facies, especially in certain beds where this facies interfingers with the coastal alluvial-fan facies. An *Ophiomorpha* burrow in one of these beds is figured by Squires (1981:930, fig. 6C;

Table 1. Megafossils with holotype localities in the Llajas Formation.

Brachiopoda

Eogryphus tolmani Hertlein and Grant, 1944

Gastropoda

Ancistrolepis? carolineae n. sp.

Architectonica (*Architectonica*) *llajasensis* Sutherland, 1966

Cerithiopsis llajasensis n. sp.

Conus caleocius Vokes, 1939

Cymatium (*Septa*) *janetae* Squires, 1983

Eocithara mutica californiensis (Vokes, 1937)

Exilia llajasensis Benton, 1940

Fusiturricula (*Crenaturricula*) *crenatospira domingenica* Vokes, 1939

Galeodea (*Caliagaleodea*) *californica* Clark, 1942

Galeodea (*Gomphopages*) *susanae* Schenck, 1926

Lyria andersoni Waring, 1917

Pachycrommium clarki (Stewart, 1927)

Ranella katherineae Squires, 1983

Tectarius ligniticus Vokes, 1939 (see *Benoistia unpuqaensis*)

Turritella andersoni lawsoni secundaria Merriam, 1941

Turritella andersoni susanae Merriam, 1941

Turritella meganosensis protumescens Merriam and Turner, 1937

Turritella uvasana etheringtoni Merriam, 1941 (see *T. u. applinae*)

Turritella uvasana infera Merriam, 1941

Bivalvia

Nayadina (*Exputens*) *llajasensis* (Clark, 1934)

Callocardia (*Nitidavenus*) *tejonensis* (Waring, 1914)

Pinna lewisi Waring, 1917

Pinna llajasensis Squires, 1983

Venericardia (*Pacificor*) *hornii calafia* Stewart, 1930

1983b, fig. 6E). *Chondrites*? is common in the outer shelf and slope facies.

DEPOSITIONAL ENVIRONMENTS AND STRATIGRAPHIC DISTRIBUTION OF MEGAFOSSILS

Based on sedimentologic and lithologic features of the Llajas Formation, on comparative studies of modern and ancient sedimentary sequences, and ecology of representative genera of mollusks and benthic foraminifers, the following facies have been recognized in the Llajas Formation: coastal alluvial fan, shallow marine, and outer shelf and slope with incised channels. In a vertical sense, most of the formation is transgressive (retrogradational) in that shallower facies are overlain by deeper facies. The uppermost part of the formation, however, represents a regressive (progradational) event in which the outer shelf and slope facies and associated

Table 2. Megafossils previously unreported from the Llajas Formation.

Anthozoa
?Trochocyathus striatus (Gabb, 1864)
Turbinolia dickersoni Nomland, 1916
Annelida
Rotularia tejonense (Arnold, 1909)
Scaphopoda
Dentalium (Laevidentalium) calafium Vokes, 1939
Dentalium stentor Anderson and Hanna, 1925
Gastropoda
Ancistrolepis? carolineae n. sp.
Cerithiopsis llajasensis n. sp.
Cirsotrema sp.
Laevityphis (Laevityphis) antiquus (Gabb, 1864)
Molopophorus cretaceus (Gabb, 1864)
Nerita cf. N. (Amphinerita) eorex Vokes, 1939
Neverita (Neverita) globosa Gabb, 1869
Olivella mathewsonii Gabb, 1864
Terebra californica Gabb, 1869
Bivalvia
Anomia mcgoniglenensis Hanna, 1927
Cardiomya aff. C. russelli (Hanna, 1927)
Corbula (Caryocorbula) dickersoni Weaver and Palmer, 1922
Gari aff. G. eoundulata Vokes, 1939
Glycymeris (Glycymeris) rosecanyonensis Hanna, 1927
Macoma rosa Hanna, 1927
Marcia (Mercimonia) bunkerii (Hanna, 1927)
Pitar (Calpitaria) uvasanus (Conrad, 1855)
Spondylus carlosensis Anderson, 1905
Teredo? sp.
Vertebrata
Isurus cf. I. praecursor (Leriche, 1906)
Odontaspis sp.

turbidite-filled incised channels were covered by shallow-marine facies (Squires, 1981, 1983b) (Fig. 2).

The coastal alluvial-fan facies, equivalent to the basal conglomerate depicted in Figure 1, is unfossiliferous. The zone of interfingering between this facies and the shallow-marine facies contains fairly abundant mollusks. Many of these mollusks are the same species that occur in the stratigraphically higher shallow-marine facies. Some of the mollusks, however, are restricted in their occurrence in the Llajas Formation to this zone of interfingering. These mollusks are *Nerita* cf. *N. (Amphinerita) eorex*, *Velates perversus*, *Turritella meganosensis protumescens*, *Turritella andersoni*, and *Venericardia (Pacifcor) aragonia joaquinensis*. Unidentifiable ostreid remains also characterize this zone of interfingering. At CSUN locality 542, such remains form an ostreid coquinite. *Turritella meganosensis protumescens* typically occurs as robust, thick-shelled fragments up to 5.5 cm in length. This taxon belongs to the *T. reversa* stock of Merriam (1941). According to Saul (1983), the presence of large members of this stock, as well as the presence of *Venericardia (Pacifcor) aragonia joaquinensis*, in the Llajas Formation

Table 3. Explanation of reference abbreviations for Tables 4 and 5.

A1	Abbott, 1968a
A2	Abbott, 1974
A&D	Abbott and Dance, 1982
C	Cossmann, 1901
D	Dance, 1976
D&D	Dell and Dance, 1963
E	Eisenberg, 1981
G	Grassé, 1968
Ha	Habe, 1968
H&G	Hertlein and Grant, 1972
K	Keen, 1971
K&C	Keen and Coan, 1974
Ki	Kira, 1965
L	Lindner, 1978
Ma	Marincovich, 1977
Mc	McMillan, 1968
Me	Merriam, 1941
M1	Morris, 1966
M2	Morris, 1975
N1	Nordsieck, 1968
N2	Nordsieck, 1969
O	Olsson, 1961
R	Rios, 1970
S	Schenck, 1936
T	Tebble, 1976
W&D	Weaver and duPont, 1970

indicate nearshore, shallow-water conditions. The presence of ostreid coquinites indicates similar conditions. *Nerita* occurs along shorelines today (Tables 3 and 4), and *Velates*, a closely allied but extinct genus, probably occurred in the same type of environment.

Most of the fossils in the formation occur in the shallow-marine facies proper, which can be divided into a transgressive phase and a regressive phase. The transgressive phase makes up most of the lower part of the formation. It consists of alternating laminated and bioturbated sandstone with scattered fossiliferous beds mostly confined to channels. The laminated sandstone represents storm-influenced stratification and the biogenic reworking is inter-storm activity (Squires, 1981). These deposits probably accumulated where the coastal alluvial-fan rivers emptied into the ocean. The resulting sediment buildup would have been subjected to reworking by waves (Squires, 1983b). The fossils have undergone a small distance of postmortem transport and constitute indigenous death assemblages (Squires, 1981). Many fossils show preservation of delicate features, such as protoconchs, outer lips, and ribs. There is much variability in the taxonomic composition of the fossils in these channel-fill deposits. At many localities, only one or two species of megafossils

Table 4. Recent bathymetry of extant molluscan genera of the Lajas Formation.

Genus (subgenus)	Depth range (m)	*MFR depth (m)	**References
Scaphopoda			
<i>Dentalium</i>	4–2320	7–100	A2,K,K&C,M2,R
Gastropoda			
<i>Ancilla</i>	6–87	21–70	A2,R
<i>Ancistrolepis</i>	40–200	100	K
<i>Architectonica</i>	0–134	2–37	A2,K
<i>Calyptrea</i>	0–70	0–37	A1,M1,M2,K
<i>Cerithiopsis</i>	0–823	24–60	A2,M1
<i>Cirsotrema</i>	33–274	73–137	A2,Ha,Ki
<i>Conus</i>	0–550	9–55	K,M1,R
<i>Cymatium (Septa)</i>	0–146	24–60	A2,M1,M2
<i>Cypraea</i>	0–140	9–24	A1,M1,M2,R
<i>Fusinus</i>	0–3616	18–60	A1,A2,K,K&C,Ki,M1,M2
<i>Fusiturricula</i>	56–65	60	R
<i>Galeodea</i>	7–330	8	Mc,N1
<i>Lyria</i>	0–133	2–24	Ha,K,Ki,W&D
<i>Natica (Naticarius)</i>	0–280	32–60	Ma,R
<i>Nerita</i>	0–9	0–9	K,M1,M2
<i>Neverita (Neverita)</i>	11–2860	658–1281	M
<i>Olivella</i>	0–90	0–27	A1,A2,K,K&C,R
<i>Phalium (Semicassis)</i>	18–100	37–55	Ha,Ki
<i>Polinices (Euspira)</i>	0–4794	15–200+	Ma,M1
<i>Pseudoliva</i>	0–3	0–3	C,L
<i>Ranella</i>	55–915	110	D&D
<i>Scaphander</i>	20–5200	50–160	A1,A2,K
<i>Sinum</i>	0–170	24–48	K,K&C,Ma,R
<i>Terebra</i>	0–280	4–18	K,M1
<i>Turritella</i>	4–185	26–56	K,K&C,Ki,M1
<i>Xenophora</i>	0–200	20–144	A1,A2,Ha,K,Ki,M2,R
Bivalvia			
<i>Acanthocardia</i>	0–360	5	N2,T
<i>Acila (Truncacila)</i>	7–1256	20–100	A1,A2
<i>Anomia</i>	0–550	0–9	A2,K,M1,M2
<i>Brachidontes</i>	0–31	0–24	K,M1,M2,R
<i>Callista (Costacallista)</i>	30–214	45–100	A2,R
<i>Cardiomya</i>	4–2400	60–190	K,M1,M2,Ha,R
<i>Corbula (Caryocorbula)</i>	0–823	10–27	A2,K
<i>Gari</i>	0–150	10–50	A2,Ha,M1
<i>Glycymeris</i>	0–110	9–60	A1,K,M1,M2
<i>Macoma</i>	0–1545	0–45	A1,K&C,M1,R
<i>Nemocardium</i>	9–640	25–90	A2,Ha,H&G,K,Ki,M1,K&C
<i>Nuculana (Saccella)</i>	2–1097	10–80	A2,K
<i>Ostrea</i>	0–91	0–24	H&G,K,M1,M2
<i>Pinna</i>	0–200	0–24	A2,Ha,K,M1,M2
<i>Pitar (Lamelliconcha)</i>	0–110	30–80	K,O
<i>Solena</i>		Nearshore	K
<i>Spondylus</i>	3–140	15–50	A1,K,M1,M2,R
<i>Teredo</i>		Bores into wood	A2,M2

* Most frequently reported; ** see Table 3 for abbreviations.

are present. *Turritella andersoni lawsoni* is usually one of these species. At other localities, such as CSUN locality 371, as many as 45 species of megafossils have been found.

The regressive phase of the shallow-marine facies makes up the uppermost part of the formation. It consists of bioturbated silty sandstone with minor occurrences of laminated sandstone and scattered fossiliferous units. These deposits were in slightly deeper waters than those of the transgressive phase and were less affected by storm reworking (Squires, 1983b). Fossils are unabraded, and at CSUN locality 475 articulated *Pinna lewisi* specimens were found. The fossils in the regressive phase are also interpreted to be indigenous death assemblages.

Where the sandstone of the transgressive and regressive phases of the shallow-marine facies grades into muddy siltstone of the outer shelf and slope facies, the sandstone is more silty and more bioturbated, and most of the fossils are confined to a few beds with indistinct contacts due to bioturbation (Squires, 1981).

One such bed, informally known as the "Stewart bed" (Squires, 1979, 1981, 1983b), is the most distinctive fossiliferous unit in the shallow-marine facies. This 1-m-thick layer occurs in the uppermost part of the transgressive phase of the shallow-marine facies in the northern part of the study area and can be traced laterally for about 10 km eastward from the type section of the formation. Fossils in the lower part of the "Stewart bed" show less evidence of postmortem transport than those elsewhere in the shallow-marine facies. Many of the taxa are represented by nearly complete growth series (with only the early juvenile individuals lacking). Articulation of valves is also common. There is a nearly 1:1 ratio of opposite valves of the bivalves *Crassatella uvasana* and *Venericardia (Pacifcor) hornii calafia*. Some specimens of these bivalves, especially *Crassatella*, are articulated but are not in growth position. Specimens of all taxa show preservation of delicate morphologic features. There is random orientation of the faunal remains. Most of the specimens occur in the lower 50 cm of the bed and seem to be somewhat concentrated in indistinct pods. Based on the above features, as well as the lack of sedimentary structures indicative of high energy, it is interpreted that a residual (winnowed) paleocommunity, as defined by Fagerstrom (1964), occurs at many exposures of the lower part of the "Stewart bed" (Squires, 1981).

The uniformity of the lithology throughout the "Stewart bed" suggests uniform depositional and environmental conditions. The megafauna is also fairly uniform throughout the bed. The most abundant faunal elements are carnivorous naticid gastropods (*Eocernina* and *Pachycrommium*), herbivorous gastropods (*Turritella* and *Ectinochilus*), infaunal suspension feeder bivalves (*Crassatella* and *Venericardia*), and carnivorous solitary ahermatypic scleractinian corals (*Trochocyathus?*). This *Eocernina*-*Turritella*-*Crassatella*-*Trochocyathus?* paleocommunity is best developed at and in the vicinity of CSUN locality 374, with 50 species of megafossils present. The shallow-marine "Stewart bed" was deposited near the shelf/slope break based on calcareous nanofossil studies (Filewicz and Hill, 1983) and on the presence

of outer shelf and slope deposits directly above it. The presence of abundant large specimens of *Trochocyathus?* in the "Stewart bed," as well as in a few thin beds a few meters above the "Stewart bed" at the type section, is consistent with a shelf/slope break environment for this part of the Llajas. Solitary ahermatypic scleractinian corals tolerate a wide range of temperatures and live at all depths, attaining their best development along margins of the continental shelves (Wells, 1957; Heckel, 1972).

Megafossils which characterize the transgressive phase of the shallow-marine facies are *Pseudophragmina (Proporocyclina) clarki*, *Cylichnina tantilla*, *Ectinochilus (Macilentos) macilentus*, *Eocernina hannibali*, *Pachycrommium clarki*, *Turritella andersoni lawsoni*, *Turritella biwaldana*, *Brachiodontes (Brachiodontes) cowlitzensis*, and *Dentalium (Laevidentalium) calafium*. The only taxon that characterizes the regressive phase of the shallow-marine facies is *Macoma rosa*.

Megafossils which commonly occur in both the transgressive and regressive phases of the shallow-marine facies are *Calyptrea diegoana*, *Phalium (Semicassis) tuberculiformis*, *Turritella uvasana applinae*, *Corbula (Caryocorbula) dickersoni*, and *Glycymeris (Glycymeris) rosecanyonensis*.

Many of the molluscan genera of the shallow-marine facies of the Llajas are extant and most commonly occur today in seas less than 80 m depth (Tables 3 and 4). The discocyclinid foraminifers lived in very shallow water (below tide level to perhaps 100 m) (Vaughan, 1945). Small calcareous benthic foraminifers present in the transgressive and regressive phases of the shallow-marine facies of the formation are indicative of inner to middle neritic conditions (Schymiczek, 1983a, 1983b).

Megafossils are scarce in the outer shelf and slope facies, but foraminifers indicative of bathyal depths are common (Squires, 1981; Schymiczek, 1983a, 1983b). The mollusks that occur in this facies also occur in the shallow-marine facies. Apparently, many of the outer shelf and slope facies mollusks are shallow-marine species that were transported into the deeper water facies. This is especially true for the mollusks at CSUN locality 541. This locality is from the base of a turbidite-filled channel in the outer shelf and slope facies. Some of the fossils occur as fragments.

PALEOCLIMATE

West Coast Eocene megafauna have long been assigned to tropical or subtropical environments (Arnold, 1909; Dickerson, 1917; Smith, 1919; Clark and Vokes, 1936; Berthiaume, 1938; Vokes, 1940; Durham, 1950). Among the Eocene molluscan genera that Durham (1950) listed as particularly characteristic of tropical (20°C or warmer), the following also occur in the Llajas Formation: the gastropods *Ancilla*, *Architectonica*, *Conus*, *Cypraea*, *Ectinochilus* [= *Rimella*], *Eocernina*, *Eocithara* [= *Harpa*], *Ficopsis*, *Paraseraphs* [= *Terebellum*], *Pseudoliva*, *Terebra*, *Turritella*, *Velates*, *Xenophora*; the bivalves *Corbula*, *Pinna*, *Pitar*, *Spondylus*, large *Venericardia*, *Crassatella* [= *Crassatellites*]; and the cephalopod *Aturia*.

Table 5. Recent, marine faunal regions (Ross, 1974:4) of extant molluscan genera of the Llajas Formation.

Genus (subgenus)	Boreal	Warm temperate	Tropical	*References
Scaphopoda				
<i>Dentalium</i>	x	x	M	D,K,R
Gastropoda				
<i>Ancilla</i>			M	A2,D,R
<i>Ancistrolepis</i>	M			A&D,E,Ha,K
<i>Architectonica</i>		x	M	A2,K,M2
<i>Calyptraea</i>	x	x	M	A1,D,K,M1,M2
<i>Cerithiopsis</i>	x	x	M	A2,K,K&C,M1
<i>Cirsotrema</i>		x	M	A2,Ha,Ki,K
<i>Conus</i>	x	x	M	K,M1,R
<i>Cymatium (Septa)</i>		x	M	A2,D,E,K,M1,M2
<i>Cypraea</i>		x	M	A1,K,L,M1,R
<i>Fusinus</i>	x	x	M	A1,A2,D,K,Ki,M1,M2
<i>Fusiturricula</i>			M	A&D,R
<i>Galeodea</i>		M	x	D,E,Ha,Mc,N1
<i>Lyria</i>		x	M	A2,Ha,K,Ki,W&D
<i>Natica (Naticarius)</i>		x	M	Ma,R
<i>Nerita</i>			M	K,L,M1,M2
<i>Neverita (Neverita)</i>	M	x		M
<i>Olivella</i>	x	x	M	A2,D,K,K&C,R
<i>Phalium (Semicassis)</i>	x	x	M	E,Ha,Ki,L
<i>Polinices (Euspira)</i>	x	x	M	Ma
<i>Pseudoliva</i>			M	C,G,L
<i>Ranella</i>	x	M		D,E
<i>Scaphander</i>	x	M	x	A1,A2,D,K,M2
<i>Sinum</i>		x	M	K,K&C,Ma,R
<i>Terebra</i>		x	M	D,K,M1
<i>Turritella</i>		x	M	K,K&C,Ki,M1,Mc
<i>Xenophora</i>		x	M	A1,A2,Ha,K,Ki,M2,R
Bivalvia				
<i>Acanthocardia</i>	x	M		D,E,L,N2,T
<i>Acila (Truncacila)</i>	M	M	x	A1,S
<i>Anomia</i>	x	M	x	A2,D,K,L,M1,M2
<i>Brachidontes</i>	x	x	M	D,K,M1,M2,R
<i>Callista (Costacallista)</i>		x	M	A2,L,R
<i>Cardiomya</i>	x	x	M	Ha,K,M1,M2,R
<i>Corbula (Caryocorbula)</i>		x	M	A2,K
<i>Gari</i>	x	x	M	A2,D,Ha,L,M1
<i>Glycymeris</i>	x	x	M	A1,K,M1,M2
<i>Macoma</i>	M	M	x	A1,D,M1,R
<i>Nemocardium</i>	x	x	M	A2,D,Ha,H&G,K,Ki,M1
<i>Nuculana (Saccella)</i>	x	x	M	A2,K
<i>Ostrea</i>	x	x	M	D,H&G,K,M1,M2
<i>Pinna</i>	x	x	M	A2,D,Ha,K,M1,M2
<i>Pitar (Lamelliconcha)</i>			M	K,O
<i>Solena</i>			M	K
<i>Spondylus</i>		x	M	D,K,M1,M2
<i>Teredo</i>	x	M	x	A2,M2

x = Present, M = Most frequently reported occurrence. * See Table 3 for abbreviations.

Berthiaume (1938) and Durham (1950) also mentioned that discocyclinid foraminifers are indicative of tropical or subtropical environments. All the recorded species of American Discocyclinidae occur in tropical, subtropical, and south temperate latitudes (Vaughan, 1945).

More recent and independent evidence supports a tropical to subtropical environment interpretation for West Coast Eocene faunas. Mineralogical analyses of kaolinite and quartz-rich, buried-soil profiles in northwest Baja California and southwest California indicate that humid tropical climatic conditions prevailed during Paleocene to mid-Eocene time (Peterson and Abbott, 1979).

Based on oxygen isotope compositions of Tertiary planktic foraminifer tests throughout the world, Savin, Douglas, and Stehli (1975) concluded that ocean temperatures remained warm and relatively constant from Paleocene through middle Eocene time. Kennett (1982) has similarly stated that during the Paleocene and Eocene, world climates were relatively warm and equable with low pole-to-equator temperature gradients. He further stated that a late Paleocene warming trend culminated in a period of peak warming during the early Eocene to early middle Eocene. This interval of time coincides with the age of the Llajas Formation. Such equable conditions ceased in earliest Oligocene time with the appearance of a worldwide cooling trend. This cooling was associated with the development of circum-Antarctic circulation (Kennett et al., 1975; Kennett, 1982; Zinsmeister, 1982).

Although 56 percent of the molluscan genera collected from the shallow-marine facies of the Llajas Formation are extant (Tables 3 and 5), the percentage is not high enough to permit accurate generic comparison studies with modern molluscan faunas like those done by Addicott (1970) for Oligocene, Miocene, and Pliocene molluscan faunas of the West Coast. Generic comparison studies with modern molluscan faunas are also difficult to do with early Tertiary faunas because of the likelihood of significant changes in environmental tolerance in progressively older faunas (Addicott, 1970). Nevertheless, a general comparison with modern molluscan faunas can be made. Most of the extant molluscan genera of the shallow-marine facies of the Llajas most commonly occur today in tropical seas (Tables 3 and 5). It should be noted also that most of these genera can occur in warm-temperate seas as well.

The taxa *Ancilla*, *Pseudoliva*, *Nerita*, *Pitar* (*Lamelliconcha*), and *Solena* are particularly significant as they are confined to tropical waters today. In addition, several of the extinct generic and subgeneric taxa in the Llajas fauna, including *Ectinochilus*, *Eocernina*, *Eocithara* [= *Harpa*], *Ficopsis*, *Gomphopages*, *Laevityphis*, *Lyriscapa* [= *Volutocris-tata*], and *Exputens*, have modern analogues that are also tropical or subtropical in distribution (Clark and Vokes, 1936; Palmer, 1967; Givens, 1974).

The presence of large *Turritella* (i.e., *T. meganosensis protumescens*) in the Llajas is indicative of shallow waters that were warmer than are presently found at this latitude (Saul, 1983).

A small percentage of the Llajas megafauna does have a

temperate water aspect to it. *Acanthocardia* and *Ranella* are most commonly found in temperate seas today. *Ancistrolepis?* and *Neverita* (*Neverita*) are strictly cold-water gastropods (Tables 3 and 5). *Acanthocardia* is most abundant in the "Stewart bed," and *Ranella* and *Ancistrolepis?* were found only in this bed. *Neverita* (*Neverita*) was found at about the same horizon as the "Stewart bed." Most likely, their presence in or near the "Stewart bed," which was deposited near the shelf/slope break, was due to "tropical submergence." This phenomenon has been observed in modern mollusks (Ekman, 1953). Many cold-water mollusks that occur in shallow water at higher latitudes have been found to inhabit only deeper water of similar temperature in the tropics.

AGE

The Llajas Formation is late early Eocene through early middle Eocene in age, based on mollusks, benthic foraminifers, and calcareous nannofossils. Assignment to European Standard Ages, various standard plankton zones, and West Coast provincial benthic foraminifer and molluscan stages is shown in Figure 3.

Prior to 1936, early workers using mollusks reported the age of the Llajas Formation as Eocene (Waring, 1914, 1917; Kew, 1919, 1924) or middle Eocene (Clark, 1921, 1926; Cushman and McMasters, 1936).

Clark and Vokes (1936) informally proposed five molluscan provincial Eocene "Stages": namely "Meganos," "Capay," "Domengine," "Transition," and "Tejon." They recognized two faunal zones in their "Capay Stage," and they assigned the Llajas Formation to the upper zone of the "Capay Stage" through the "Transition Stage." Givens (1974) showed that their upper faunal zone of the "Capay" should be considered part of the "Domengine Stage," and he restricted the use of "Capay Stage" to their lower faunal zone of the "Capay Stage." It is in this restricted sense that "Capay Stage" is used herein.

Saul (1983) regarded the "Meganos Stage" as late Paleocene-early Eocene, the restricted "Capay Stage" of Givens (1974) as early Eocene, the "Domengine" as late early through early middle Eocene, and the "Transition" as middle Eocene. These ages are used for this present report (Fig. 3). Weaver et al. (1944) regarded the "Tejon" as late Eocene, and Givens and Kennedy (1979) regarded it as late middle Eocene and/or late Eocene. Such ages are used for this present report (Fig. 3).

Merriam and Turner (1937) reported that in the Llajas Formation the "Capay Stage" is represented by the "basal conglomerate" because of the presence of *Turritella meganosensis protumescens*, a subspecies regarded by them as an index fossil for the "Capay Stage." Based on this present study, this subspecies occurs only where the basal conglomerate (coastal alluvial-fan facies) interfingers with the shallow-marine facies.

Vokes (1939) assigned the lower part of the Llajas Formation to the lower "Capay Stage" based, in part, on the presence of *Galeodea sutterensis*. I was unable to find any *G. sutterensis* in the Llajas. Vokes did not figure his *Galeodea*

species from the Llajas Formation, nor did he give any locality information or catalog numbers of the specimen(s). Vokes (1939) assigned the middle part of the Llajas Formation to the upper "Capay Stage" based on the presence of *Galeodea susanae*, which can be documented as a Llajas species (i.e., CSUN locality 371). The "*G. susanae* Zone" of Clark and Vokes (1936) was originally assigned to the upper part of the "Capay Stage," but it was shown to be faunally indistinguishable from the "Domengine Stage" by Givens (1974) and was reassigned to the "Domengine Stage."

Vokes (1939) also used the presence of *Fusiturricula* (*Crenaturricula*) *crenatospira* in the "Lower Llajas" as an indicator of the "Capay Stage." He noted the presence of *F. (C.) crenatospira domenginica* in the "Upper Llajas" and considered this subspecies confined to the "Domengine Stage." In this present study, *F. (C.) crenatospira* was found only in the "Stewart bed" (just above the middle of the formation) where it is associated with *F. (C.) crenatospira domenginica*. *F. (C.) crenatospira domenginica*, furthermore, occurs in strata below the "Stewart bed."

Merriam (1941) reported the presence of *Turritella andersoni susanae* and *T. uvasana infera* from the "basal conglomerate" of the Llajas Formation. In this present study, *T. andersoni susanae* is considered equivalent to *T. andersoni*. As with *T. meganosensis protumescens*, these taxa occur in the Llajas Formation only where the coastal alluvial-fan facies interfingers with the shallow-marine facies. *T. andersoni* is a "Capay Stage" index fossil. Although it has not been previously reported from the Llajas Formation, Weaver et al. (1944) assigned the lower part of the Llajas Formation to their "Capay" *Turritella andersoni* Zone. The rest of the Llajas Formation was assigned to the "Domengine" and lower "Transition" "Stages" by Weaver et al. (1944).

Squires (1981, 1983a, 1983b) and Saul (1983) reported the lowermost mollusk-bearing beds of the Llajas Formation to be late early Eocene in age and the rest of the fossil-bearing beds as early middle Eocene in age.

Based on the above discussions, it is concluded that the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine facies is assignable to the *Turritella uvasana infera* fauna of the restricted "Capay Stage" of Givens (1974) which is equivalent to the lower of the two faunal zones of the "Capay Stage" of Clark and Vokes (1936), Vokes (1939), and Weaver et al. (1944). Due to the presence of many "Domengine" molluscan species associated with the "Capay" species where the coastal alluvial-fan facies interfingers with the shallow-marine facies, it is probable that most of the "Capay Stage" is not represented in the Llajas Formation. The part that is present is probably near the "Capay-Domengine" boundary. Saul (1983) put this boundary near the P8-P9 boundary of the "Standard" planktic foraminiferal zonation scheme as used by Berggren, Kent, and Flynn (in press) (Fig. 3). Saul (1983) also noted that most of the "Capay Stage" is probably missing in the Simi Valley area. The uppermost "Capay Stage" part of the Llajas Formation, therefore, probably corresponds to latest early Eocene time.

Fossil-bearing rocks of the Llajas Formation, therefore,

cannot be assigned to any molluscan stage older than the *Turritella uvasana infera* fauna of the "Capay," as used in the restricted sense of Givens (1974). As noted by Saul (1983), no mollusks restricted to Clark and Vokes' (1936) older "Meganos Stage" have been recovered from the Llajas Formation. Although *T. uvasana infera* and *T. andersoni susanae* have been reported from the upper 100 m of the Meganos-age Santa Susana Formation, specimens are variants slightly different from those at the type localities low in the Llajas (Merriam, 1941; Saul, 1983). Filewicz and Hill (1983) reported a hiatus of approximately 4 million years between the Llajas Formation and the underlying Santa Susana Formation. In this present study, this hiatus is considered to be more on the order of 3 million years (Fig. 3).

The remaining part of the Llajas Formation is associated with megafossils that have been reported (Vokes, 1939; Merriam, 1941; Verastegui, 1953; Rehder, 1973; Givens, 1974, 1979; Givens and Kennedy, 1979; Saul, 1983) elsewhere on the West Coast only from the "Domengine Stage." These taxa are *Conus caleocius*, *Eocithara mutica californiensis*, *Fusinus teglandae*, *Fusiturricula* (*Crenaturricula*) *crenatospira domenginica*, *Lyriscaapha lajollaensis*, *Molopophorus cretaceus*, *Olequahia domenginica*, *Proximitra?* *cretacea*, *Pseudoliva lineata*, *Turritella andersoni lawsoni*, *Turritella uvasana applinae*, *Xenophora stocki*, *Claibornites diegoensis*, *Pitar* (*Lamelliconcha*) *joaquinensis*, and *Venericardia* (*Pacificor*) *hornii calafia*.

Additional evidence for a "Domengine" age for the Llajas Formation is the overlap or joint occurrence of taxa that have been reported (Givens, 1974; Givens and Kennedy, 1979) elsewhere on the West Coast as having their lowest stratigraphic occurrence in the "Domengine Stage," including *Ficopsis cooperiana*, *Laevityphis* (*Laevityphis*) *antiquus*, *Ranellina pilsbryi*, *Terebra californica*, *Glycymeris* (*Glycymeris*) *roseacanyonensis*, and *Glyptoactis* (*Glyptoactis*) *domenginica*; with taxa that have been reported (Givens, 1974; Givens and Kennedy, 1979) elsewhere as having their highest stratigraphic occurrence in the "Domengine Stage," including *Architectonica* (*Stellaxis*) *cognata*, *Ectinochilus* (*Macilentos*) *macilentus*, *Pseudoperissolax blakei praeblakei*, *Velates perversus*, and *Nayadina* (*Exputens*) *llajasensis*.

Based on calcareous nannofossils and mollusks in the Llajas Formation, Saul (1983) reported the "Domengine Stage" to be of late early through early middle Eocene age.

Strata assignable to the middle Eocene "Transition Stage" were not recognized in the Llajas Formation in this present study. The unique association of molluscan species that is utilized in recognizing this "stage" (Givens, 1974; Givens and Kennedy, 1979) was not found in the Llajas Formation.

Workers using benthic foraminifers have reported the age of the Llajas Formation as middle Eocene (Cushman and McMasters, 1936) or early to middle Eocene (Laiming, 1940a, 1940b, 1943; Mallory, 1959; Schymiczek, 1983a, 1983b).

Laiming (1940a, 1940b, 1943) assigned the Llajas Formation to the B-3 (upper part), B-2, B-1, and B-1A "Zones" of his tentative benthic foraminiferal zonation scheme. He correlated these "zones" to the upper "Capay" through "Domengine" molluscan "Stages" of Clark and Vokes (1936).

Mallory (1959) reported that the lower Llajas corresponds to his Penutian Stage (lower Eocene, "Capay") and that the bulk of the formation corresponds to his Ulatisian Stage (middle Eocene, "Domengine to Transition"). An updated version of these benthic foraminiferal stages, now known to be time-transgressive, is given in Poore (1980). Schymiczek (1983a, 1983b) assigned the Llajas Formation to the Ulatisian Stage. Givens and Kennedy (1979) have concluded that the "Domengine Stage" is correlative with the Ulatisian (and probably in part Penutian) Stage.

Using the calcareous nannofossil biostratigraphic zones of Okada and Bukry (1980) and the absolute dates assigned to these zones by Berggren, Kent, and Flynn (in press), Filewicz and Hill (1983) reported that most of the shallow-marine (transgressive) facies of the Llajas Formation is of latest early Eocene or earliest middle Eocene age (*Discoaster lodoensis*–*D. sublodoensis* Zones, CP11–CP12). The uppermost 30 m or so of this facies (*Discoasteroides kuepperi* Subzone, CP12a) and the outer shelf and slope facies are of middle Eocene age (*Rhabdosphaera inflata* Subzone, CP12b–CP13, to *Nannotetrina quadrata* Zone, CP13). *Rhabdosphaera inflata* first occurs 4 m above the "Stewart bed." These results are summarized in Figure 3.

According to Filewicz and Hill (1983), the *R. inflata* Subzone plots within the TE2.1 global, eustatic sea-level cycle of Vail, Mitehum, and Thompson (1977), and the sudden shift to upper bathyal waters just above the "Stewart bed" may be in response to both a steady increase in sea level and tectonism.

CORRELATION

Correlations between California and Oregon/Washington can be easily accomplished with molluscan assemblages of middle and early late Eocene age because these mollusks occupied a single faunal province (Armentrout, 1975).

Twenty-two (or 42 percent) of the species listed by Givens and Kennedy (1979) for the "Domengine Stage" Mount Soledad, Ardath Shale, and Scripps Formations of the La Jolla Group near San Diego, California also occur in the Llajas Formation. All three formations yield *Turritella andersoni lawsoni*. In addition, the Ardath Shale yields *T. uvasana applinae* and has planktic foraminifers correlative with P10/11 Zones and calcareous nannofossils correlative with the CP12 Zone (Givens and Kennedy, 1979).

Most of the megafauna of the late early through middle age Eocene Maniobra Formation, Orocopa Mountains, southeastern California is conspecific with that of the Llajas Formation. The lower part of the formation has calcareous nannofossils indicative of CP9 through CP11. *Turritella andersoni lawsoni* is present in the upper part of the formation (Crowell and Susuki, 1959; Advocate, 1982).

As mentioned earlier, the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine facies of the Llajas Formation can be correlated to the *Turritella uvasana infera* fauna described by Givens (1974). This fauna is from the lowermost part of the Juncal Formation, Pine Mountain area, California. Fifteen (or 40 percent) of the

species restricted to the *Turritella uvasana applinae* fauna described by Givens (1974) from the upper half of the Juncal Formation in the same area occur also in the Llajas Formation above the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine facies. This Juncal Formation fauna corresponds to the upper of the two faunal zones of the "Capay Stage" of Clark and Vokes (1936) through the "Domengine Stage" (Givens, 1974, fig. 6).

Twenty-seven (or 69 percent) of the megafossil species listed by Squires (1977) from the "Domengine-Transition" "Stages" unnamed stratigraphic unit E₂, lower Piru Creek area, Transverse Ranges, California, also occur in the Llajas Formation.

In central California, the megafaunas of both the Avenal Sandstone (Stewart, 1946) and the Domengine Formation (Vokes, 1939) are similar to that of the Llajas.

In southwestern Oregon, the megafaunas in the Umpqua and Tyee Formations, as used by Turner (1938), are similar to that in the Llajas Formation. Turner (1938:32) assigned most of the Umpqua Formation megafauna to the "Capay Stage." He locally subdivided the Umpqua into lower and upper portions, and he considered the upper portion of his Glide section as possibly intermediate between the "Capay" and "Domengine" "Stages." He assigned the Tyee megafauna to the "Domengine Stage."

Turner's "lower Umpqua" now corresponds to the Roseburg Formation, and his "upper Umpqua" includes both the Lookingglass and Flourney Formations (Baldwin, 1974). The base of the Lookingglass Formation is considered by Baldwin to coincide with the division between Turner's "lower" and "upper Umpqua." Based on a study of planktic foraminifers, Miles (1981) assigned the Roseburg Formation to Zone P7–8 of the "Standard" zonation, the Lookingglass Formation to Zone P7–8, and the Flourney Formation to Zone P10. He assigned the Tyee Formation to an early middle Eocene age.

Miles (1981), in his study of the southwestern Oregon Eocene strata, placed the "Capay-Domengine" boundary near the P9–10 boundary, but Saul (1983) has pointed out that this molluscan stage boundary actually should lie near the P8–9 boundary. Using Miles' (1981) figures 3 and 7 and Saul's (1983) refinement of the "Capay-Domengine" boundary, the Roseburg and Lookingglass Formations can be shown to be equivalent to the "Capay Stage" and the Flourney Formation to be equivalent to the "Domengine Stage."

Miles (1981, fig. 7) assigned most of the Llajas Formation to early Eocene time, but such an age assignment does not conform to the findings of this present report or to the findings of Filewicz and Hill (1983), Schymiczek (1983a, 1983b), or Saul (1983).

BIOGEOGRAPHY

The widespread aspect of West Coast warm-water Eocene faunas can be demonstrated by the recognition of some of Clark and Vokes' (1936) Eocene "stages" from southern California (latitude 33°N) to as far north as the Gulf of Alaska (latitude 60°N) (Addicott, 1970). About 30 percent of the Llajas molluscan species, for example, ranged from San Die-

go into Oregon/Washington. Two other species, *Acila* (*Truncacila*) *decisa* and *Nuculana* (*Saccella*) *gabbii*, ranged from southern California to Kamchatka.

Clark and Vokes (1936) used the presence of *Velates per-versus*, which occurs in the lower part of the Llajas, as evidence of a seaway connection in the tropical Central American region between the Atlantic Ocean and the waters of the West Coast of North America. *Velates* is predominantly Tethyan in its distribution and has been found in Western Europe, Africa, Asia, Burma, West Pacific, Jamaica, Florida, Panama, and southern and central California (Vokes, 1935; Clark and Vokes, 1936; Palmer, 1967). It was a shallow-water mollusk indicative of tropical and subtropical climate, as are species of the subgenus *Pacificor* of the bivalve *Venericardia* (Palmer, 1967) which also occur in the Llajas.

The discocyclinid foraminifer *Pseudophragmina* (*Proporocyclina*) *clarki* has been found in Florida, Mexico, and Peru, as well as along the West Coast (Cole and Applin, 1964; Blondeau and Brabb, 1983). The presence of this species in the Llajas Formation is additional evidence of the seaway connection mentioned above.

Clark and Vokes (1936) also cited the presence of *Clavilithes* n. sp. A and *Cryptochorda californica* from the Llajas as further evidence of a Central American seaway connection because these species are closely related, respectively, to *Clavilithes scalaris* and *Cryptochorda stromboides* from the Paris Basin Eocene. Other Llajas megafauna species used as evidence for the seaway are *Clavilithes tabulatus*, *Lyria andersoni*, and *Eocithara mutica californiensis*, which are closely related, respectively, to *Clavilithes parisiensis*, *Lyria maga*, and *Eocithara mutica* of the Paris Basin Eocene (Clark and Vokes, 1936; Vokes, 1937). Some other Llajas species which have been noted as similar to ones from the Paris Basin Eocene are *Callocardia* (*Nitidavenus*) *tejonensis* [= *Isocardia*] which resembles *Cytherea nitida* from France (Vokes, 1939) and *Benoistia umpquaensis* which closely resembles *B. brevicula* from France (Givens and Kennedy, 1976).

Gardner and Bowles (1934) commented upon middle Eocene gastropod species from the Chiapas locality, Isthmus of Tehuantepec, southern Mexico (Atlantic side), that are closely related to ones from the Llajas Formation. These species from Chiapas are *Cernina* (*Eocernina*) *chiapasensis*, *Amaurellina malinchae*, *Amaurellina cortezi*, and *Volutocristata chiapasensis*, which are closely related, respectively, to *Eocernina hannibali*, *Tejonia moragai*, *Pachycrommium clarki*, and *Lyriscapha lajollaensis* from the Llajas. Gardner and Bowles (1934) inferred that the two areas were once connected by a seaway.

Givens (1979), in a detailed study of *Lyriscapha*, concluded that this genus, which is present in the shallow-marine (transgressive) facies of the Llajas, probably evolved in the Caribbean region during Paleocene or early Eocene time. It subsequently spread northward during the middle Eocene or it immigrated from the Old World Tethyan biogeographic province. Entrance into the Pacific Coast region of North America was by way of a narrow seaway connection across southern Central America (Costa Rica, Panama) or northwestern South America (Givens, 1979).

According to Zinsmeister (1983a), the first indication of the influx of large numbers of mollusks from the Gulf Coast and the Caribbean into western North America was in the late Paleocene, and this influx of immigrants continued in the early Eocene. "It is not known whether these immigrants came in distinct pulses associated with major tectonic events in Central America or represent a continuous long-term westward migration of Caribbean taxa into the Pacific as a result of a general climatic warming during the Eocene" (Zinsmeister, 1983a:66).

Most of the megafauna genera of the Llajas Formation were already present on the West Coast by Llajas time. In addition, several species of the Llajas megafauna were carry-overs from earlier times. The Llajas taxa *Calyptraea diegoana*, *Pseudoperissolax blakei praeblakei*, *Olivella mathewsonii*, *Scaphander* (*Mirascapha*) *costatus*, *Surculites mathewsonii*, *Acila* (*Truncacila*) *decisa*, *Nemocardium linteum*, and *Nuculana* (*Saccella*) *gabbii* have been reported from late Paleocene "Martinez Stage" strata on the West Coast (Nelson, 1925; Weaver, 1953; Smith, 1975; Zinsmeister, 1974, 1983a). The Llajas taxa *Turbinolia dickersoni*, *Polinices* (*Euspira*) *nuciformis*, and *Schizaster diabloensis* have been reported from late Paleocene strata on the West Coast (Clark and Woodford, 1927; Quayle, 1932; Marincovich, 1977). The Llajas taxa *Neverita* (*Neverita*) *globosa*, *Turritella uvasana infera*, and *Brachidontes* (*Brachidontes*) *cowlitzensis* have been reported from late Paleocene-early Eocene "Meganos Stage" strata on the West Coast (Givens, 1974; Saul, 1983).

Several genera immigrated into the West Coast region during Llajas time. Equatorial paleocirculation of surface waters was still largely unrestricted worldwide during Llajas time and until at least 45 million years ago (middle Eocene), even though the Tethyan Seaway was closing up due to compressive tectonic forces (Kennett, 1982). As mentioned earlier, migration from points east of the West Coast was accomplished by means of a narrow seaway across southern Central America or northwestern South America (Woodring, 1966; Givens, 1977, 1979; Zinsmeister, 1983a). Molluscan genera/subgenera present in the Llajas Formation and coeval strata but not in older Tertiary strata of the West Coast will be discussed below. Unless otherwise noted, biogeographic data for these genera were obtained from Wenz (1938-1944), Palmer and Brann (1965-1966), Cox et al. (1969), Palmer (1974), Marincovich (1977), and Moore (1983), as well as from the "Systematics" portion of this present report.

Architectonica (*Stellaxis*), *Paraseraphs*, and *Strepsidura* possibly arrived during the early Eocene (uppermost "Capay" part), most likely from the Caribbean province. *Domenginella* apparently originated on the West Coast at this time, possibly as a northern variant of *Scobinella*, as suggested by Vokes (1939).

Benoistia and *Megistostoma* arrived during the late early-early middle Eocene ("Domengine") on the West Coast from the Tethyan province. *Eocithara* (see Rehder, 1973), *Natica* (*Naticarius*), *Ranella* (see Squires, 1983a), and possibly *Conus*, *Phalium* (*Semicassis*), and *Marcia* (*Mercimonia*) arrived during this time, most likely from the Caribbean region. *Lyriscapha* (see Givens, 1979) may have arrived from either

the Caribbean or Tethyan regions. *Cymatium (Septa)* (see Squires, 1983a), *Galeodea (Caliagaleodea)*, *Olequahia*, *Tenionia*, *Glyptoactis (Glyptoactis)*, and possibly *Proximitra?* originated on the West Coast at this time. *Ancistrolepis?* probably arrived during the early middle Eocene from the Pacific Northwest.

In summary, the influx of mollusks into western North America that Zinsmeister (1983a) commented on continued, at least, into the early middle Eocene. As noted by Smith (1975), the megafauna of the Lajas Formation is of mixed origins, having cosmopolitan, Tethyan, Caribbean, and North American elements.

SYSTEMATIC MATERIALS AND METHODS

From 1978 to 1983, an intensive and meticulous search of the Lajas Formation was undertaken by the author in order to amass megafossil specimens that would represent the composition and the stratigraphic distribution of the fauna more accurately than the cursory collections on which previous workers based their reports. About 5000 specimens were obtained from 132 localities, permitting the addition to the known fauna of many rare species that otherwise would not have been found. Numerous return visits were made to several of the richest localities. Several hundred man-hours were spent quarrying CSUN locality 374 ("Stewart bed") and CSUN locality 371. Because specimens with preservation superior to those previously figured were obtained and because many of the holotypes of species erected for Lajas Formation specimens are from localities that are either unknown or only vaguely known, most of the holotypes are not refigured.

Systematic arrangement of the generic and higher taxonomic categories follows that of Cole (1964) for the large foraminifer; Wells (1956) for the scleractinians; Muir-Wood, Elliott, and Hatari (1965) for the brachiopod; Howell (1962) for the annelid tube; Ludbrook (1960) for the scaphopod; Cox et al. (1969) and Vokes (1980) for the bivalves; Miller (1947) for the nautiloid; Jeletzky (1966) for the sepiid; Glaessner (1969) for the brachyuran; Fischer (1966) for the echinoid; and Compagno (1973) for the sharks. The systematic arrangement of Wenz (1938–1944) is followed generally for the gastropods.

Most of the figured specimens are on deposit in the Natural History Museum of Los Angeles County, Invertebrate Paleontology section. Figured specimens borrowed from the paleontology collections of the University of California, Los Angeles, Department of Earth and Space Sciences are on deposit there. Additional unfigured specimens are on deposit in the Department of Geological Sciences Paleontology collection, California State University, Northridge.

The synonymies are selective. Works that include original figures and/or descriptions are listed. References that add pertinent and documentable biostratigraphic information are also included. More complete synonymies of many of the gastropods and bivalves can be found in Stewart (1927, 1930).

Primary type material, molluscan stage range, geographic distribution, local occurrence, and remarks are listed for all

the species. Unless otherwise noted, such data are derived from references listed in the synonymies or from new data obtained in the course of this present study. "Primary type material" refers to the holotype, paratype(s), syntypes, lectotype, paralectotype(s), or neotype of the senior subjective synonym of each taxon. In the case of homonyms, the junior homonym "primary type material" is listed, and if the new name "primary type material" is different it is listed also. The molluscan stages are for the West Coast, and they are from Clark and Vokes (1936) and Weaver et al. (1944), with refinements made by Givens (1974) and Saul (1983). The stages are provisional, hence the names are placed in quotation marks. The relative age of each stage and correlation with various biostratigraphic zones are shown in Figure 4. Any taxa stage range extensions that are the result of this present study of the Lajas material are so mentioned under the "Remarks" for each species. Locality information for all the localities mentioned in this report is given in the "Localities" section.

Letter abbreviations used for catalog and/or locality numbers are:

ANSP = Academy of Natural Sciences of Philadelphia

CAS = California Academy of Sciences

CIT = California Institute of Technology

CSUN = California State University, Northridge

MCZ = Museum of Comparative Zoology, Harvard

HS = Herman Schymiczek (CSUN master's thesis field station)

LACMIP = Los Angeles County Museum, Invertebrate Paleontology Section

SU = Stanford University (collections now housed at the California Academy of Sciences)

UCMP = University of California Museum of Paleontology (Berkeley)

UCLA = University of California, Los Angeles

UCR = University of California, Riverside

UO = University of Oregon

USGS = United States Geological Survey (Washington, D.C. register)

USNM = United States National Museum of Natural History

UW = University of Washington

SYSTEMATICS

Phylum Protista

Subphylum Sarcodina

Class Rhizopodea

Subclass Granuloreticulosia

Order Foraminiferida

Suborder Rotaliina

Superfamily Orbitoidacea

Family Discocyclinidae Galloway, 1928

Genus *Pseudophragmina* Douvillé, 1923

Type Species. By original designation, *Orthophragmina floridana* Cushman, 1917.

Pseudophragmina (Proporocyclina) clarki
(Cushman, 1920)

Figures 5a–b

Orbitolites sp. A Arnold, 1910:pl. 3, fig. 6.

Orthophragmina clarki Cushman, 1920:41–42, pl. 7, figs. 4–5.

Discocyclina clarki (Cushman). Schenck, 1929:221, figs. 1–2, 5, text fig. 7. Keenan, 1932:pl. 4, figs. 1–2. Vaughan, 1936:255–256, pl. 43, figs. 1–2. Berthiaume, 1938:496, pl. 61, fig. 12. Turner, 1938:7, 12, 21. Stewart, 1946:table 1. Shepard, Lankford, and Milow, 1957:columnar section.

Discocyclina cloptoni Vaughan. Cushman and McMasters, 1936:516, pl. 77, figs. 6–9. [Misidentification *vide* Schymiczek, 1983b:50.] Vaughan, 1945:98–99, pl. 42, fig. 2.

Pseudophragmina (Proporocyclina) clarki (Cushman). Vaughan, 1945:104, 106. Cole, 1958:419–420, pl. 52, figs. 3–11. Crowell and Susuki, 1959:589. Mallory, 1959:259. Cole and Applin, 1964:47, pl. 9, figs. 1–4. Blondeau and Brabb, 1983:47, pl. 6, fig. 17, and table 5.

Pseudophragmina clarki (Cushman). Schymiczek and Squires, 1981:989. Squires, 1983b:fig. 9i.

Primary Type Material. Holotype and paratype, USNM collections, upper Lodo Formation, northeast side of Domengine Creek near the corner of the SW ¼ of section 29, T 18 S, R 15 E, Domengine Ranch quadrangle, California.

Molluscan Stage Range. “Capay” through “Domengine.”

Geographic Distribution. Florida, Mexico, Peru through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 457, 469I, 470b, 472, 473, 477, 479, 487, 491, 504, 511, 522, 527a, 527b, 548.

Remarks. Specimens are essentially confined to the shallow-marine (transgressive) facies. Most occur in several 50-cm-thick beds approximately 100 m above the base of the formation (e.g., localities 457, 469I, 487, 511, 527b). In such beds, the tests are concentrated in small pods. *Turritella andersoni lawsoni* may or may not occur with the tests, but if present it is usually the only associated megafossil or the most abundant megafossil. The tests of *P. (P.) clarki* are mostly complete, unabraded, and 1.5 to 7 mm in diameter.

The stratigraphic highest occurrence of the specimens in the Lajas Formation is at locality 473, about 14 m above the “Stewart bed” at the type section. The bed that locality 473 occurs in probably represents a shallow-marine (transgressive) facies bed that interfingers with the outer shelf and slope facies.

Phylum Coelenterata

Subphylum Cnidaria

Class Anthozoa

Subclass Zoantharia

Order Scleractinia

Suborder Caryophylliina

Superfamily Caryophylliicae

Family Caryophylliidae Gray, 1847

Subfamily Caryophylliinae Gray, 1847

Genus *Trochocyathus*

Milne-Edwards and Haime, 1848

Type Species. By subsequent designation (Milne-Edwards and Haime, 1850b), *Turbinolia mitrata* Goldfuss, 1827.

?*Trochocyathus striatus* (Gabb, 1864)

Figure 5c

Trochomilia striata Gabb, 1864:207–208, pl. 26, fig. 195.

Trochocyathus striatus (Gabb). Vaughan, 1900:101–102, pl. 7, fig. 24; pl. 8, figs. 1–3. Dickerson, 1913:265. Hanna, 1927:269.

Primary Type Material. UCMP holotype 12256, Division B, near Mt. Diablo, California.

Molluscan Stage Range. “Capay”?; Domengine.

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 438, 444, 445, 447, 451, 458, 459, 471c, 472, 473, 477, 479, 480, 493, 494, 495, 496, 500, 510, 525.

Remarks. ?*Trochocyathus striatus* occurs primarily in the “Stewart bed.” At a few localities (e.g., locality 374) there is a partial growth series, with the early juveniles missing. Most specimens in the Lajas Formation are complete, unattached, and unabraded.

Specimens at locality 473 occur in a bed that probably represents a shallow-marine facies bed that interfingers with the outer shelf and slope facies.

The genus and species of the most abundant coral in the Lajas Formation are questioned because of a lack of modern comparative taxonomic work on middle Eocene solitary scleractinian ahermatypic corals. The type of this taxon is largely imbedded in matrix and probably cannot be well enough prepared to make a valid comparison (Durham, 1981, pers. commun.).

Dickerson (1913) reported *T. striatus* from “Capay”-age strata in central California, but he gave no specific locality information nor did he figure the species. For these reasons, the “Capay” age occurrence is uncertain.

Subfamily Turbinoliinae

Milne-Edwards and Haime, 1848

Genus *Turbinolia* Lamarck, 1816

Type Species. By subsequent designation (Milne-Edwards and Haime, 1850b), *Turbinolia sulcata* Lamarck, 1816.

Turbinolia dickersoni Nomland, 1916

Figures 5d–e

Turbinolia dickersoni Nomland, 1916:61, pl. 3, figs. 5–8. Palmer, 1923:306, pl. 56, figs. 2, 4. Quayle, 1932:98–99, pl. 6, figs. 1–5.

Primary Type Material. UCMP holotype 12020 (missing since 1932), Cerros Shale Member of the Lodo Formation, UCMP locality 1817.

Molluscan Stage Range. Upper Paleocene through “Domengine.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 467.

Remarks. Only four specimens were found in the Lajas Formation. This small coral is distinguished from the much larger *?Trochocyathus striatus* by the presence of a stellate columella. This columella does not project noticeably above the corallum wall.

The type locality of this species is in the lower part of the Cerros Shale Member (late Paleocene age) or the Lodo Formation (Marincovich, 1977:252; Moore, 1983:A88).

Clark (1926:114) reported this species from “Domengine”-age strata in central California, but such a report is uncertain because of his lack of locality data. The presence of this species at CSUN locality 467 does extend, with certainty, its molluscan stage range into the “Domengine Stage.”

Phylum Brachiopoda

Class Articulata

Order Terebratulida

Suborder, Superfamily, and Family UNKNOWN

Genus *Eogryphus* Hertlein and Grant, 1944

Type Species. By original designation, *Eogryphus tolmani* Hertlein and Grant, 1944.

Eogryphus tolmani Hertlein and Grant, 1944

Figure 5f

Eogryphus tolmani Hertlein and Grant, 1944:89–90, pl. 5, figs. 1–3, 7; pl. 18, figs. 1, 9–11; text figure 22.

Primary Type Material. UCLA holotype 6203, CAS paratypes 7279–7282; all from upper Lajas Formation, upper Las Lajas Canyon, 3000 feet north and 1500 feet east of the southwest corner of section 23, T 3 N, R 17 W (Hertlein and Grant, 1944:89).

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 438, 468a, 515, 525.

Remarks. Many specimens were found at and near the vicinity of locality 438. Many of the specimens are articulated. Plotted on the topographic map available in 1944, the locality of the type specimens probably plots about 1500 feet

(457 m) east of CSUN locality 515 in an area in which slope wash has covered the exposures. The southwest corner of section 23 was unmarked and had to be projected. The locality of the type specimens, however, is in the general vicinity of all the CSUN localities in which specimens of *Eogryphus tolmani* were found.

Smith (1975:470) reported *Eogryphus* cf. *E. tolmani* from the “Martinez Stage” (Paleocene) part of the Lodo Formation, central California.

Phylum Annelida

Class Polychaetia

Order Sedentaria

Family Serpulidae Lamarck, 1818

Genus *Rotularia* Defrance, 1827

Type Species. By original designation, *Serpula spirulaea* Lamarck, 1818.

Rotularia tejonense (Arnold, 1910)

Figure 5g

Spiroglyphus? tejonensis Arnold, 1910:51, pl. 4, fig. 18. Dickerson, 1916:pl. 37, figs. 5a–b. Vokes, 1939:162–163, pl. 20, figs. 20–22. Stewart, 1946:pl. 11, fig. 21.

?Tubulostium tejonense (Arnold). Keen and Bentson, 1944:195.

Rotularia tejonense (Arnold). Nilsen, 1973:table 1. Squires, 1977:table 1.

Primary Type Material. USNM holotype 165658, Avenal Formation, USGS locality 4617.

Molluscan Stage Range. “Capay” through “Transition.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 703. Shallow-marine (transgressive) facies: CSUN localities 374, 444, 445, 494, 521, 546.

Remarks. Most specimens were found in the “Stewart bed” encrusting other shells, most notably *Ostrea*.

According to Clark (1921:table 1), *R. tejonense* [= *Spiroglyphus* (?) *tejonensis*] occurs in “Meganos” age strata. Such a report, however, cannot be substantiated at this time because of his lack of locality information and because his rock unit names are not clearly defined.

Phylum Mollusca

Class Scaphopoda

Family Dentaliidae Gray, 1834

Genus *Dentalium* Linné, 1758

Type Species. By subsequent designation (Montfort, 1810), *Dentalium elephantinum* Linné, 1758.

Dentalium stentor Anderson and Hanna, 1925

Figure 5h

Dentalium stentor Anderson and Hanna, 1925:145, pl. 13, fig. 17.

Dentalium stentor? Anderson and Hanna. Squires, 1977:table 1.

Primary Type Material. CAS holotype 819, Tejon Formation, CAS locality 792.

Molluscan Stage Range. "Domengine" through "Tejon."

Geographic Distribution. Simi Valley through southern San Joaquin Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 374, 444, 445, 447, 449, 451, 493, 494, 500, 510.

Remarks. Abundant large, thick-shelled specimens were found locally in the "Stewart bed" (locality 374 and vicinity). Although some specimens are nearly complete (up to 75 mm in height), no apices were found. Due to the absence of apices, the specimens could not be assigned with certainty to any subgenus of *Dentalium*.

Subgenus *Laevidentalium* Cossman, 1888

Type Species. By original designation, *Dentalium incertum* Deshayes, 1825.

Dentalium (Laevidentalium) calafium

Vokes, 1939

Figure 5i

Dentalium (Laevidentalium) calafium Vokes, 1939:105, pl. 16, figs. 30–31. Squires, 1983b:fig. 9h.

Primary Type Material. UCMP lectotype 15750, Domengine Formation, UCMP locality A-1027; UCMP paralectotype 15751, Domengine Formation?, UCMP locality A-1003.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 455, 466, 467, 484, 491, 499, 500, 507, 508, 510, 529b, 538, 539, 548.

Remarks. Specimens occur in channel-fill deposits in the Lajas Formation. They are small, smooth, and fragmented specimens. The presence of the apical notch on the convex side of the shell serves to distinguish this taxon.

Vokes (1939) designated two syntypes (UCMP 15750 and 15751) but no holotype for his species. In accordance with the International Code of Zoological Nomenclature (1964) article 74, therefore, UCMP 15750 is herein designated as the holotype of *D. (L.) calafium*.

Class Gastropoda

Subclass Prosobranchia

Order Archaeogastropoda

Superfamily Neritacea

Family Neritidae Rafinesque, 1815

Subfamily Neritinae Rafinesque, 1815

Genus *Nerita* Linné, 1758

Type Species. By subsequent designation (Montfort, 1810), *Nerita peloronta* Linné, 1758.

Nerita cf. *N. (Amphinerita) eorex*

Vokes, 1939

Figure 6a

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 700, 701.

Remarks. Specimens were found only in the "Capay Stage" portion of the Lajas Formation. A total of 22 specimens was found, and all but two specimens were from locality 700. Due to the presence of well-cemented matrix in the aperture area of each specimen, the labial areas could not be studied. The small specimens have a very low spire, large body whorl, and a smooth shell surface. Apparently, there is no umbilicus, and the outer lip is not dentate.

The specimens most closely resemble *N. (A.) eorex* Vokes (1939:180–181, pl. 22, figs. 24, 26, 29) from the Domengine Formation, Reef Ridge area, California. Vokes (1939) regarded this species as the only smooth-shelled *Nerita* from the West American Eocene.

Genus *Velates* de Montfort, 1810

Type Species. By original designation, *Velates conoideus* Montfort, 1810 [= *Nerita perversa* Gmelin, 1791].

Velates perversus (Gmelin, 1791)

Figures 6b–c

Nerita perversa Gmelin, 1791:vol. 1, pt. 6, p. 3686.

Velates conoideus Montfort, 1810:355.

Velates perversus (Gmelin). Vokes, 1935:382–383, pl. 25, figs. 1–5; pl. 26, figs. 1–2. Clark and Vokes, 1936:875, pl. 1, figs. 7–8. Givens, 1974:61, pl. 5, figs. 5–6, 13. Givens and Kennedy, 1979:83.

Primary Type Material. No holotype was designated by Gmelin (1791). Gmelin did not have a collection but worked mainly from the literature, according to Smith (1970:459). Gmelin (1791) lists the Chemnitz Cabinet as the source of his *Nerita perversa*, and if the Cabinet is still extant, the lectotype could be designated.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Western Europe, Africa, Asia, Burma, West Pacific, Jamaica, southern and central California.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 700, 701, 702.

Remarks. Specimens were found only in the "Capay Stage" portion of the Lajas Formation. Except at locality 701, only fragments were found. A very large specimen (diameter 70

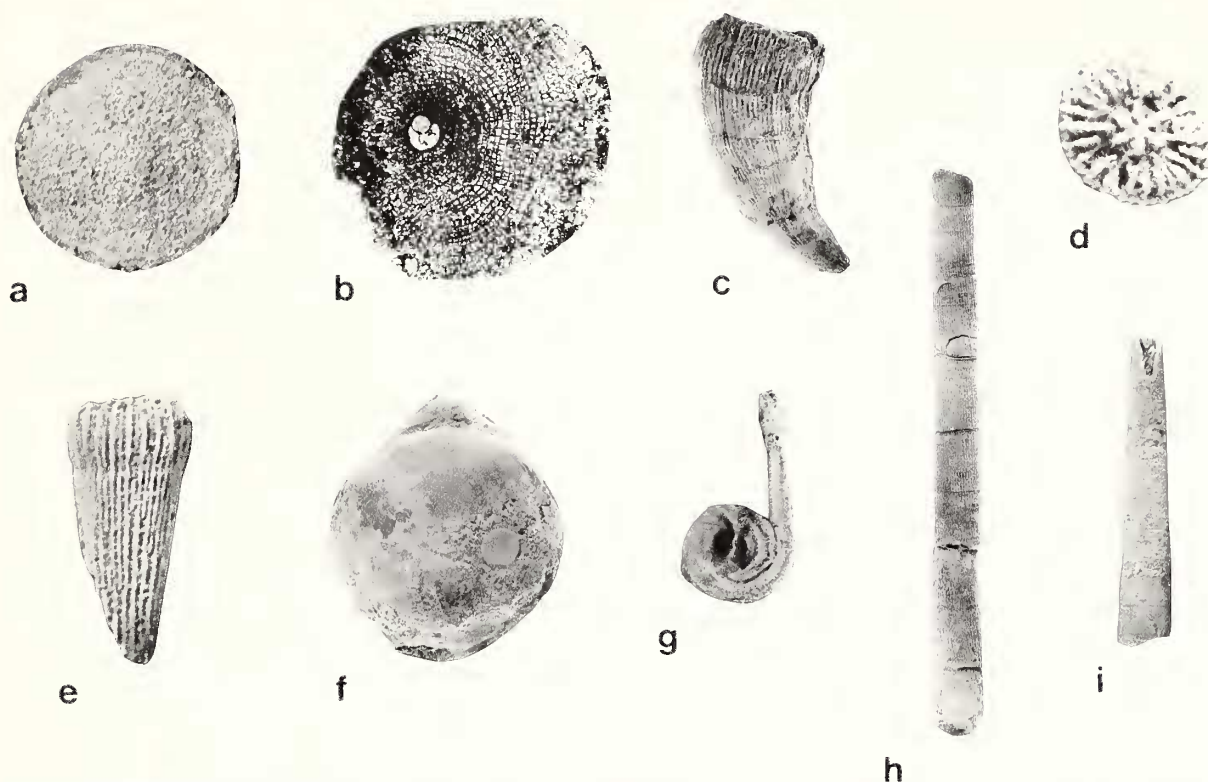


Figure 5. Llajas Formation large benthic foraminifer, solitary corals, brachiopod, calcareous worm tube, and scaphopods. **a and b.** *Pseudophragmina (Proporocyclina) clarki* (Cushman, 1920). **a**, test exterior, LACMIP hypotype 6500, CSUN loc. 511, $\times 8$. **b**, equatorial section, LACMIP hypotype 6501, HS loc. HS-A-11(4), $\times 25$. **c.** *?Trochocyathus striatus* (Gabb, 1864), lateral view, LACMIP hypotype 6502, CSUN loc. 374, $\times 1$. **d and e.** *Turbinolia dickersoni* Nomland, 1916, LACMIP hypotype 6503, CSUN loc. 467. **d**, dorsal view, $\times 7$. **e**, lateral view, $\times 5$. **f.** *Eogryphus tolmani* Hertlein and Grant, 1944, dorsal view, LACMIP hypotype 6504, CSUN loc. 438, $\times 0.75$. **g.** *Rotularia tejonense* (Arnold, 1910), LACMIP hypotype 6505, CSUN loc. 444, $\times 1.5$. **h.** *Dentalium stentor* Anderson and Hanna, 1925, partial specimen, side view, LACMIP hypotype 6506, CSUN loc. 444, $\times 1$. **i.** *Dentalium (Laevidentalium) calafium* Vokes, 1939, partial specimen, apical notch view, LACMIP hypotype 6507, CSUN loc. 373, $\times 4.5$.

cm) was found at locality 701. The best specimens from the Llajas are in the UCMP collection and are from a locality equivalent to CSUN locality 702 (i.e., UCMP locality 7193). UCMP specimen 37435 (Figs. 6b–c) is from this locality. Vokes (1935) figured two hypotypes from this same locality.

The most characteristic feature of this species is the presence of seven or eight small teeth on the inner lip.

Order Mesogastropoda

Superfamily Cerithiacea

Family Turritellidae Woodward, 1851

Genus *Turritella* Lamarck, 1799

Type Species. By monotypy, *Turbo terebra* Linné, 1758.

Turritella meganosensis protumescens Merriam and Turner, 1937

Figure 6d

Turritella meganosensis n. subsp. Clark, 1929:pl. 10, figs. 1–2.

Turritella meganosensis protumescens Merriam and Turner, 1937:104, pl. 6, figs. 8–10. Turner, 1938:85, pl. 22, fig. 15. Merriam, 1941:75–76, pl. 8, figs. 1–2, 5, 6, 8. Weaver, 1943:369–370, pl. 74, figs. 14, 18. Saul, 1983:pl. 2, fig. 1.

Primary Type Material. UCMP holotype 15353, “basal conglomerate” of the Llajas Formation, UCMP locality 7195.
Molluscan Stage Range. “Capay.”

Geographic Distribution. Simi Valley, California through southwestern Oregon.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 452, 454, 469a, 469b, 469c, 501, 542, 545.

Remarks. According to Merriam and Turner (1937:104), this taxon occurs in the basal conglomerate of the Llajas Formation. This is misleading, as specimens do not occur in the basal conglomerate proper (equivalent to the coastal alluvial-fan facies). They actually are confined to beds that represent shallow-marine facies interfingering with the coastal alluvial-fan facies. At a few of the localities, the thick-shelled, robust *T. meganosensis protumescens* exhibits growth series.

Turritella andersoni Dickerson, 1916

Figure 6c

Turritella andersoni Dickerson, 1916:501–502, pl. 42, figs. 9a–b. Turner, 1938:83, pl. 22, figs. 4–6. Merriam, 1941:76–77, pl. 9, figs. 1–2; pl. 10, figs. 1, 3–5, 8; pl. 12, figs. 1–3. Givens, 1974:62, pl. 5, figs. 7–10.

Turritella andersoni susanae Merriam, 1941:79, pl. 11, fig. 6. Saul, 1983:pl. 2, fig. 5.

Primary Type Material. UCMP holotype 12131, Domengine Formation, UCMP locality 1817.

Molluscan Stage Range. Upper “Meganos”?, “Capay.”

Geographic Distribution. Simi Valley, California through southwestern Oregon.

Local Occurrence. Upper part of Santa Susana Formation?; interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies of the Lajas Formation: CSUN localities 469d, 700.

Remarks. Only a single specimen was found at locality 469d. This specimen (Fig. 6c) consists of only 2½ whorls, but the characteristic noded three primary spiral ribs, the median one situated closer to the anterior than the posterior primary, are present.

Although the holotype (UCMP 15295, UCMP locality A-993) of *T. a. susanae* is from strata equivalent to the interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies, specimens have been reported by Merriam (1941) from the upper part of the underlying Santa Susana Formation. Saul (1983) identified these specimens with *T. andersoni* n. sp. because none has the sculpture of the Lajas specimens. Saul (1983), however, did note that some of the Santa Susana specimens are very close to *T. andersoni* Dickerson, especially from localities near the Lajas–Santa Susana contact.

Turritella andersoni lawsoni Dickerson, 1916

Figures 6f–g

Turritella lawsoni Dickerson, 1916:502, pl. 42, figs. 10a–b. Hanna, 1927:308, pl. 49, fig. 5. Hanna and Hertlein, 1943:fig. 62–15. Stewart, 1946:pl. 11, figs. 27–29.

Turritella andersoni Dickerson, Waring, 1917:pl. 15, fig. 18.

Turritella andersoni lawsoni Dickerson. Vokes, 1939:161. Merriam, 1941:77–78, pl. 9, figs. 3–8; pl. 12, fig. 4. Crowell and Susuki, 1959:pl. 2, fig. 12. Givens, 1974:62–63, pl. 5, figs. 11–12, 14. Givens and Kennedy, 1979:82–83, table 1. Saul, 1983:pl. 2, figs. 10–11. Squires, 1983b:fig. 9e.

Turritella andersoni lawsoni secundaria Merriam, 1941:78–79, pl. 9, fig. 9. Crowell and Susuki, 1959:pl. 2, fig. 11.

Turritella andersoni lawsoni forma *secundaria* Merriam. Saul, 1983:pl. 2, fig. 12.

Primary Type Material. UCMP holotype 12128, Domengine Formation, UCMP locality 2295.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. San Diego through central California.

Local Occurrence. Shallow-marine (transgressive) facies:

CSUN localities 374, 439, 440, 441, 442, 443, 444, 445, 447, 449, 453, 455, 457, 468b, 469j, 470c, 471a, 471b, 471e, 481, 485, 487, 490, 493, 494, 510, 516, 522, 523, 527a, 529a, 529b, 537, 539, 548, 704.

Remarks. *Turritella andersoni lawsoni* is one of the most abundant megafaunal components in the Lajas Formation. At many localities (e.g., 442 and 471a), it is the only megafossil present. *T. andersoni lawsoni* is restricted in the Lajas Formation to the shallow-marine (transgressive) facies. Its highest stratigraphic occurrence is the “Stewart bed,” where it is abundant. Some specimens show faint spiral ribs, whereas others do not. Some specimens, especially at locality 374, have the spiral ribs on one side but not on the other (weathered) side.

Some specimens of *T. a. lawsoni* from localities 374 and 548 are characterized by the presence of a well-developed anterior primary rib and represent the form described by Merriam (1941:78–79, pl. 9, fig. 9) as variety *secundaria*. These Lajas specimens of *T. a. lawsoni* which show the well-developed anterior primary rib are probably just ecotypes.

The primary type material of *secundaria* is UCMP 33998 from UCMP locality 7004 = CSUN locality 374.

Turritella buwaldana Dickerson, 1916

Figure 6h

Turritella buwaldana Dickerson, 1916:500–501, pl. 42, figs. 7a–b. Hanna, 1927:307, pl. 49, figs. 7–8, 12. Merriam, 1941:86–87, pl. 21, figs. 3–9; pl. 22, figs. 1–14. Stewart, 1946:pl. 11, fig. 24. Givens, 1974:63, pl. 5, fig. 15. Saul, 1983:pl. 2, figs. 13–15. Squires, 1983b:fig. 9f.

Turritella kewi Dickerson, 1916:501, pl. 42, fig. 8.

Primary Type Material. UCMP holotype 12130, Domengine Formation, UCMP locality 672.

Molluscan Stage Range. Upper “Meganos”?, “Capay”?, “Domengine” through “Tejon.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Upper part of the Santa Susana Formation?; shallow-marine (transgressive) facies of the Lajas Formation: CSUN localities 371, 372, 373, 455, 467, 469e, 469h, 469j, 484, 486, 499, 500, 505, 514, 538, 539, 540, 548, 705.

Remarks. *T. buwaldana* in the Lajas Formation is characterized by its small size and presence of three primary spiral ribs and two posterior secondaries.

T. buwaldana has been reported from the upper part of the Santa Susana Formation by Merriam (1941), but he noted that these forms are probably subspecifically distinct from those in the Lajas Formation.

Saul (1983) reported *T. b. crooki* Merriam and Turner from the “Capay” portion of the Lajas Formation. Although none was found in the present study, it is possible that *T. b. crooki* and *T. buwaldana* are the same. More taxonomic data are needed to resolve the question (Saul, 1983, pers. commun.).

Turritella uvasana infera Merriam, 1941

Figure 6i

Turritella uvasana infera Merriam, 1941:90, pl. 40, figs. 2–4. Givens, 1974:65–66, pl. 6, figs. 5–7. Saul, 1983:pl. 2, fig. 4.

Primary Type Material. UCMP holotype 33993, “basal conglomerate” of the Lajas Formation, UCMP locality A-994 = CSUN locality 452; UCMP paratypes 15439 and 15443, upper part of the Santa Susana Formation, UCMP locality 7000.

Molluscan Stage Range. Upper “Meganos” through “Capay.”

Geographic Distribution. Simi Valley and Pine Mountain area, southern California.

Local Occurrence. Upper part of the Santa Susana Formation; interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies of the Lajas Formation: CSUN localities 452, 705.

Remarks. According to Merriam (1941:90), this taxon occurs in the basal conglomerate of the Lajas Formation. This is misleading, as specimens do not occur in the basal conglomerate proper (equivalent to the coastal alluvial-fan facies). They actually are confined to beds that represent shallow-marine facies interfingering with the coastal alluvial-fan facies.

T. u. infera has been reported from the upper part of the Santa Susana Formation, but the specimens are slightly different variants that have more rounded whorl profiles and heavier ribbing than those from the type locality in the Lajas Formation (Merriam, 1941; Saul, 1983).

Adult whorls of the Lajas specimens have six to seven primary spiral ribs with the posteriormost two more closely spaced and somewhat weaker than the other spiral ribs. Secondary ribs are generally absent.

The illustrated specimen (Fig. 6i) is the same one used by Saul (1983:pl. 2, fig. 4).

Turritella uvasana applinae Hanna, 1927

Figure 6j

Turritella applini Hanna, 1927:307, pl. 49, figs. 1, 4. Clark, 1929:pl. 10, figs. 8, 18.

Turritella uvasana applini Hanna. Merriam, 1941:93–94, pl. 16, figs. 5–6; pl. 18, fig. 2.

Turritella uvasana etheringtoni Merriam, 1941:94, pl. 15, figs. 12–15. Squires, 1977:table 1.

Turritella uvasana applinae Hanna. Givens, 1974:66, pl. 6, figs. 3–4; pl. 7, fig. 19. Givens and Kennedy, 1979:82–83, table 1. Saul, 1983:pl. 2, fig. 18. Squires, 1983b:fig. 9g.

Primary Type Material. UCMP holotype 30971, La Jolla Formation, UCMP locality 3993; UCMP paratype 33894, La Jolla Formation, UCMP locality 3990.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. San Diego through Pine Mountain area, southern California.

Local Occurrence. Shallow-marine (transgressive) facies:

CSUN localities 371, 374, 440, 444, 449, 469e, 469i, 471d, 471e, 481, 484, 486, 491, 500, 507, 529a, 539, 548, 704. Outer shelf and slope facies: CSUN locality 483. Shallow-marine (regressive) facies: CSUN localities 475, 489, 512b, 512d.

Remarks. Lajas specimens of *T. u. infera* superficially resemble *T. u. applinae*, but the latter has a more convex whorl profile, many more primary spiral ribs, and the presence of numerous well-developed secondary ribs.

The primary type material for *T. u. etheringtoni* is from the Lajas Formation: UCMP holotype 33875, UCMP locality 7003; UCMP paratypes 33876 and 33877, UCMP locality 7004 = CSUN locality 374. Specimens of *T. u. applinae* are especially abundant at locality 374.

Family Architectonicidae Gray, 1850

Genus *Architectonica* Röding, 1798

Type Species. By subsequent designation (Gray, 1847), *Trochus perspectivus* Linné, 1758.

Subgenus *Architectonica* s.s.

Architectonica (Architectonica) llajasensis
Sutherland, 1966

Figure 6k

Architectonica llajasensis Sutherland, 1966:1–4, figs. 1–2.

Primary Type Material. LACMIP holotype 1140, Lajas Formation, LACMIP locality 461-B.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371.

Remarks. Only three specimens were found, and these are from the locality in Devil Canyon. Judging from the megafauna associated with Sutherland’s (1966) holotype specimen, the type locality of *A. llajasensis* is probably near CSUN locality 444 in the “Stewart bed.”

This species is placed in *Architectonica* s.s. because the umbilicus is bordered by two serrated ridges (see Sutherland, 1966), a characteristic of typical *Architectonica* (Stewart, 1927:343).

Subgenus *Stellaxis* Dall, 1892

Type Species. By original designation, *Solarium alveatum* Conrad, 1833.

Architectonica (Stellaxis) cognata
Gabb, 1864

Figure 6l

Architectonica cognata Gabb, 1864:117, pl. 20, figs. 72, 72a, 72c, not d and e as stated [not 72b = *A. alveata* (Conrad) *vide* Stewart, 1927:344].

Stellaxis cognata (Conrad). Waring, 1917:98.

Architectonica cognata Gabb. Givens and Kennedy, 1979:83, table 1.

Architectonica (Stellaxis) cognata Gabb. Stewart, 1927:343–344, pl. 28, figs. 7–8. Turner, 1938:90, pl. 18, fig. 17. Vokes, 1939:163–164. Stewart, 1946:pl. 11, fig. 4. Weaver, 1943:363–364, pl. 73, fig. 20; pl. 103, fig. 19. Givens, 1974:68, pl. 7, figs. 1–3.

Primary Type Material. ANSP lectotype 4223, Tejon Formation s.l., 11 km south of Martinez, California.

Molluscan Stage Range. Uppermost “Capay” through “Domengine.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 452, 702, 703. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 373, 374, 444, 447, 455, 486, 490, 491, 538, 704.

Remarks. This species is characterized mostly by a single keel on the periphery of the whorls (Givens, 1974:68). The Llajas specimens have this prominent keel, as well as a less prominent sutural cord, thereby producing an apparent double-keel look. The sutural cord is exposed due to the removal of the shell material in the suture region.

A previously assigned “Capay” age (Turner, 1938; Givens, 1974) for the lower range limit of this species was based on occurrence in the “upper Umpqua” Formation of southwestern Oregon. The “upper Umpqua,” however, is actually equivalent to both the “Capay” and “Domengine” “Stages” (Baldwin, 1974; Miles, 1981). A lower range limit of uppermost “Capay,” nevertheless, can be substantiated by the occurrence of this species in the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine (transgressive) facies of the Llajas Formation.

Family Cerithiidae Fleming, 1828

Subfamily Cerithiinae Fleming, 1828

Genus *Benoistia* Cossmann, 1899

Type Species. By original designation, *Cerithium muricoides*.

Benoistia umpquaensis Turner, 1938

Figure 6m

Benoistia umpquaensis Turner, 1938:82, pl. 21, figs. 8, 10. Weaver, 1943:387, pl. 76, figs. 11–12.

Tectarius ligniticus Vokes, 1939:164–165, pl. 21, figs. 1, 3, 4.

Benoistea umpquaensis Turner. Givens and Kennedy, 1976:964–965, pl. 1, figs. 14–21.

Primary Type Material. UCMP holotype 33192, “upper Umpqua” Formation, UCMP locality A-661.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only a single specimen was found, and it is from

the “Stewart bed.” See Givens and Kennedy (1976) for a detailed morphologic description of this species.

The holotype of *Tectarius ligniticus* is UCMP 15838, Llajas Formation, UCMP locality 7005.

Family Cerithiopsidae H. and A. Adams, 1854

Genus *Cerithiopsis* Forbes and Hanley, 1853

Type Species. By monotypy, *Murex tubercularis* Montagu, 1803.

Cerithiopsis llajasensis n. sp.

Figures 6n–o

Diagnosis. A species of *Cerithiopsis* characterized by teleoconch sculpture of four to five primary spiral ribs crossed by equal-strength collabral costae, with nodes at the intersections. The varices are irregularly spaced.

Cerithiopsis llajasensis n. sp. is similar to *C. orovillensis* Dickerson (1916:489–490, pl. 39, fig. 7) from Eocene strata in northern California. *C. llajasensis* differs from the holotype of *C. orovillensis* in the following features: larger, a more elongate-slender shape, equal strength spiral and collabral ribs on the teleoconch whorls, equal-strength primary spiral ribs, less nodose sculpture, more varices, and an absence of two strong spiral keels above the base of the body whorl.

Cerithiopsis llajasensis n. sp. is similar also to *C. excelsus* Dall (1909:75, pl. 3, fig. 9) from Eocene strata in southwestern Oregon. Givens (1974) regarded *C. excelsus* as *C. excelsum* (Dall). *C. llajasensis* differs from the holotype of *C. excelsum* in the following features: suture more adpressed, absence of a shoulder on the whorls, equally spaced collabral sculpture, fewer primary spiral ribs, equal-strength primary spiral ribs, many more varices, and more swollen varices. The cancellate sculpture of *C. llajasensis* is equal in strength over the shell whereas in *C. excelsum* this is not the case. *C. excelsum* has two prominent spiral ribs and unequally spaced collabral sculpture, thereby producing an uneven cancellate sculpture.

Description. Shell small, turritiform and elongate, with many convex whorls. Suture moderately impressed, undulating. Protoconch mammillated, about $3\frac{1}{2}$ whorls, smooth. Teleoconch sculpture cancellate, nodes at intersections of primary spiral ribs and collabral costae. Spiral and collabral sculpture equal strength. Four to five primary spiral ribs per whorl; seven on body whorl proper, five more on base of body whorl. Ribs equally spaced, usually separated by a secondary riblet. No secondary riblets on base of body whorl. Fourteen to 16 collabral costae per whorl. Costae equally spaced, extending from suture to suture. No collabral ornament on base of body whorl. Swollen varices irregularly spaced, usually two per whorl.

Columella smooth, covered by a thin callus. Aperture ovate. Anterior canal short, shallowly notched, bent backwards. Dimensions of largest specimen, height (incomplete) 22.5 mm, body whorl width 6 mm.

Primary Type Material. LACMIP holotype 6515, LACMIP paratype 6516, Llajas Formation, CSUN locality 371.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 489, 491, 498, 517.

Remarks. Specimens of this new species are abundant at locality 371, but preservation is only fair in most of the specimens. The type specimens have the best overall preservation. Fifteen specimens were found at locality 373, one specimen each from localities 489 and 491, and three specimens each from localities 498 and 517. Preservation is not as good at these other localities as it is at locality 371.

The bent-backwards anterior canal of this species is well developed enough to suggest assignment to *Cerithiopsis*. *Bitittium* is similar to *Cerithiopsis* in having a short and shallow anterior canal, but according to Houbrick (1977) the canal is not bent backwards in *Bitittium*.

Etymology. The species is named for the Lajas Formation.

Superfamily Epitoniacea

Family Epitoniidae Lamarck, 1822

Genus *Cirsotrema* Mörch, 1852

Type Species. By monotypy, *Scalaria varicosum* Lamarck, 1822.

Cirsotrema sp.

Figure 6p

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only a single specimen was found, and it is from the "Stewart bed." This genus is characterized by thick axial varices more or less reflexed posteriorly and usually not continuous from whorl to whorl; coarse primary spiral ribs; and basal disk bounded by a prominent enlargement of the varices. A species identification could not be made as parts of the aperture and basal keel area are missing.

Superfamily Calyptraeacea

Family Calyptraeidae Blainville, 1824

Genus *Calyptraea* Lamarck, 1799

Type Species. By monotypy, *Patella chinensis* Linné, 1758.

Calyptraea diegoana (Conrad, 1855)

Figure 6q

Trochita diegoana Conrad, 1855:7, 17; 1857:327, pl. 5, fig. 42.

Galerus excentricus Gabb, 1864:136, pl. 20, fig. 95; pl. 29, fig. 232a. Dickerson, 1913:264.

Calyptraea calabasaensis Nelson, 1925:419, pl. 54, figs. 8a-b.

Calyptraea (Galerus) calabasaensis Nelson. Clark and Woodford, 1927:120, pl. 21, figs. 10-13.

Calyptraea diegoana (Conrad). Stewart, 1927:340-341, pl. 27, fig. 15. Turner, 1938:89-90, pl. 20, figs. 1-2. Weaver, 1943:351-352, pl. 71, figs. 16, 20; pl. 103, fig. 3; 1953:29.

Stewart, 1946:pl. 11, fig. 5. Kleinpell and Weaver, 1963:186, pl. 24, fig. 7. Hickman, 1969:79, 82, pl. 11, figs. 7-8; 1980:33-34, pl. 2, figs. 18-21. Smith, 1975:469, table 1. Givens and Kennedy, 1979:table 2.

Primary Type Material. USNM holotype 1856, Tejon? horizon, San Diego, California.

Molluscan Stage Range. "Martinez" through lower Oligocene.

Geographic Distribution. San Diego, California through Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 455, 491, 548. Shallow-marine (regressive) facies: CSUN localities 462, 475, 512d.

Remarks. Specimens were most abundant at locality 371. At all localities, the specimens are unattached.

Family Xenophoridae Philippi, 1853

Genus *Xenophora* Fischer von Waldheim, 1807

Type Species. By subsequent designation (Gray, 1847), *Trochus conchyliophorus* Born, 1780.

Xenophora stocki Dickerson, 1916

Figure 6r

Xenophora stocki Dickerson, 1916:502-503, pl. 37, figs. 4a-b. Givens, 1974:71, pl. 7, fig. 8. Givens and Kennedy, 1979:tables 1, 3.

Primary Type Material. UCMP holotype 11838, Rose Canyon Shale, UCMP locality 2226.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego through Pine Mountain area, southern California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 444, 458, 471d, 472, 477, 479.

Remarks. *Xenophora stocki* is most abundant in the "Stewart bed," especially at locality 374. Specimens at all localities occur as internal molds with only remnants of shell material.

Superfamily Strombacea

Family Strombidae Rafinesque, 1815

Genus *Ectinochilus* Cossmann, 1889

Type Species. By original designation, *Strombus canalis*.

Subgenus *Macilentos* Clark and Palmer, 1923

Type Species. By original designation, *Rimella macilenta* White, 1889.

Ectinochilus (Macilentos) macilentus (White, 1889)

Figure 6s

Rimella macilenta White, 1889:19, pl. 3, figs. 10-12.

Ectinochilus (Macilentos) macilentus (White). Clark and Palmer, 1923:280, pl. 51, figs. 9-10. Givens, 1974:72, pl. 7, figs. 13, 16. Squires, 1977:table 1; 1983b:fig. 9b.

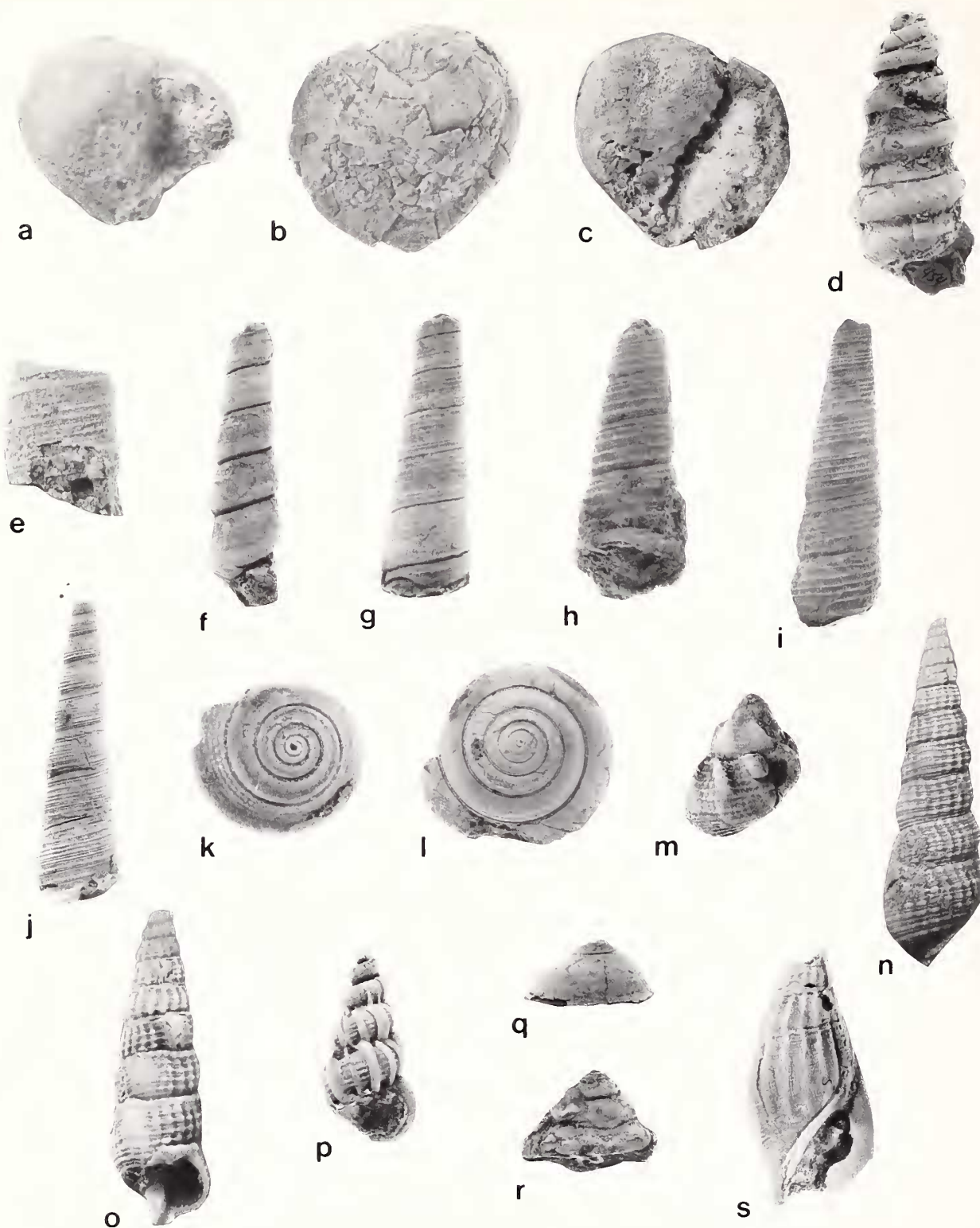


Figure 6. Lajas Formation gastropods. Unless otherwise indicated, views are apertural. **a.** *Nerita* cf. *N. (Amphinerita) eorex* Vokes, 1939, LACMIP hypotype 6508, CSUN loc. 700, $\times 6$. **b and c.** *Velates perversus* (Gmelin, 1791), UCMP hypotype 37435, UCMP loc. 7193 = CSUN loc. 702, $\times 1.3$. **b.** abapertural view. **d.** *Turritella meganosensis protumescens* Merriam and Turner, 1937, LACMIP 6509, CSUN loc. 454, $\times 1$. **e.** *Turritella andersoni* Dickerson, 1916, LACMIP hypotype 6510, CSUN loc. 469d, $\times 2$. **f and g.** *Turritella andersoni lawsoni* Dickerson, 1916. All parts from CSUN loc. 374 and $\times 1.25$. **f.** LACMIP hypotype 6511. **g.** LACMIP hypotype 6512. **h.** *Turritella buwaldana* Dickerson,

Rimella (Macilentos) macilenta White. Vokes, 1939:155–156, pl. 20, figs. 1, 2, 4, 5.

Ectinochilus macilentus (White). Stewart, 1946:93, pl. 11, figs. 12–15. Givens and Kennedy, 1979:83, table 1.

Primary Type Material. USNM holotype 20114, Domengine Formation, about 3 km north of New Idria, section 16, T 17 S, R 12 E, Priest Valley quadrangle, Fresno County, California; CAS paratype 769, Llajas Formation, CAS locality 393.

Molluscan Stage Range. “Capay” through “Domengine.”

Geographic Distribution. San Diego through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 373, 374, 440, 444, 445, 447, 449, 455, 458, 460, 471d, 472, 481, 484, 491, 493, 494, 498, 499, 508, 518, 538, 539. Outer shelf and slope facies: CSUN locality 482.

Remarks. This species is common in the shallow-marine (transgressive) facies. The two localities at which it is most abundant are 371 and 374. At 371 specimens are very well preserved and some have the protoconch or the fragile outer lip intact.

The diagnosis of the subgenus *Macilentos* by Clark and Palmer (1923) was based on the paratype and other specimens from the Llajas Formation, rather than on White’s holotype from central California.

Family Seraphsidae Jung, 1974

Genus *Paraseraphs* Jung, 1974

Type Species. By original designation, *Paraseraphs tetanus* Jung, 1974 [= *Terebellum fusiforme* of authors, not of Lamarck].

Paraseraphs erraticus (Cooper, 1894)

Figure 7a

Tornatina erratica Cooper, 1894:47, pl. 2, fig. 35. Waring, 1917:pl. 15, fig. 11.

Terebellum californicum Vokes, 1939:157, pl. 20, figs. 7–8, 11.

Terebellum (Terebellum) erraticum (Cooper). Kleinpell and Weaver, 1963:189, pl. 25, figs. 8–9.

Paraseraphs erraticus (Cooper). Jung, 1974:41, pl. 12, figs. 8–14; pl. 13, figs. 1–3. Givens and Kennedy, 1979:87, tables 1, 3.

Primary Type Material. CAS holotype 608, Eocene strata, Rose Canyon, San Diego, California.

Molluscan Stage Range. Uppermost “Capay” through “Transition.”

Geographic Distribution. San Diego through central California.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 469d, 702. Shallow-marine (transgressive) facies: CSUN localities 371, 540.

Remarks. Only a few specimens were found, and most are from locality 371. The largest specimen (Fig. 7a) is 35 mm in height and is nearly twice the size of the holotype.

The presence of *P. erraticus* in the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine (transgressive) facies of the Llajas Formation extends the molluscan stage range of this taxon into the uppermost “Capay.” Previously, the lower range limit had been reported as the “Domengine Stage” (Vokes, 1939; Jung, 1974).

Superfamily Cypraeacea

Family Cypraeidae Rafinesque, 1815

Subfamily Cypraeinae Rafinesque, 1815

Genus *Cypraea* Linné, 1758

Type Species. By subsequent designation (Montfort, 1810), *Cypraea tigris* Linné, 1758.

Cypraea castacensis Stewart, 1927

Figure 7b

Cypraea castacensis Stewart, 1927:370, pl. 28, fig. 10. Ingram, 1942:13, pl. 1, figs. 5–6.

Eocypraea castacensis (Stewart). Vokes, 1939:154, pl. 20, figs. 9, 14.

Primary Type Material. UCMP holotype 11690, Tejon? Formation, UCMP locality 452.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 444, 491.

Remarks. Specimens are relatively rare in the Llajas For-

1916, LACMIP hypotype 6513, CSUN loc. 373, $\times 3$. i. *Turritella uvasana infera* Merriam, 1941, abapertural view, UCLA hypotype 59359, UCLA loc. 6616, $\times 1.25$. j. *Turritella uvasana applinae* Hanna, 1927, LACMIP hypotype 6514, CSUN loc. 374, $\times 1$. k. *Architectonica (Architectonica) llajasensis* Sutherland, 1966, dorsal view, LACMIP 6515, CSUN loc. 371, $\times 3$. l. *Architectonica (Stellaxis) cognata* Gabb, 1864, dorsal view, LACMIP hypotype 6516, CSUN loc. 374, $\times 1$. m. *Benoistia umpquaensis* Turner, 1938, abapertural view, UCLA hypotype 59274, CSUN loc. 374, $\times 1$. n and o. *Cerithiopsis llajasensis* n. sp. All parts from CSUN loc. 371. n, LACMIP holotype 6517, $\times 3.5$. o, abapertural view, LACMIP paratype 6518, $\times 3$. p. *Cirsotrema* sp., UCLA hypotype 59275, CSUN loc. 374, $\times 1.5$. q. *Calyptrea diegoana* (Conrad, 1855), side view, LACMIP hypotype 6519, CSUN loc. 371, $\times 1.5$. r. *Xenophora stocki* Dickerson, 1916, internal mold, side view, LACMIP hypotype 6520, CSUN loc. 374, $\times 1$. s. *Ectinochilus (Macilentos) macilentus* (White, 1889), LACMIP hypotype 6521, CSUN loc. 371, $\times 1.5$.

mation. One of Vokes' (1939:154, pl. 20, fig. 9) hypotypes is from Devil Canyon, just north of locality 373.

Superfamily Naticacea

Family Naticidae Forbes, 1838

Subfamily Ampullospirinae Cox, 1930

Genus *Eocernina* Gardner and Bowles, 1934

Type Species. By original designation, *Natica hannibali* Dickerson, 1914.

Eocernina hannibali (Dickerson, 1914)

Figure 7c

Natica hannibali Dickerson, 1914:119, pl. 12, figs. 5a–b; 1916: 508, pl. 38, figs. 9a–b.

Natica (*Cryptonatica*) *hannibali* Dickerson. Waring, 1917: pl. 15, figs. 21–23.

Ampullina hannibali (Dickerson). Hanna, 1927:306, pl. 48, figs. 1–3, 10.

Ampullina (*Globularia*) *hannibali* (Dickerson). Clark, 1929: pl. 11, fig. 12.

Cernina (*Eocernina*) *hannibali* (Dickerson). Turner, 1938: 87–88, pl. 19, fig. 3. Vokes, 1939:172, pl. 22, figs. 1, 3. Weaver, 1943:348–349, pl. 71, figs. 8–9, 21, 23.

Eocernina hannibali (Dickerson). Hanna and Hertlein, 1943: fig. 62–17. Marincovich, 1977:229–231, pl. 18, fig. 14; pl. 19, figs. 1–4. Givens and Kennedy, 1979:87, tables 1, 3. Squires, 1983b:fig. 9c.

Globularia (*Eocernina*) *hannibali* (Dickerson). Stewart, 1946: pl. 11, fig. 18. Givens, 1974:75, pl. 9, figs. 1, 3. Squires, 1977:table 1.

Primary Type Material. CAS holotype 243, Umpqua Formation, CAS locality 25.

Molluscan Stage Range. “Capay” through “Transition.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 469a, 542, 545, 702, 703. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 373, 374, 439, 440, 444, 445, 447, 449, 450, 451, 455, 458, 460, 465, 469e, 469g, 470b, 471b, 471e, 477, 479, 480, 484, 486, 488, 493, 494, 497, 498, 499, 500, 508, 509, 510, 514, 517, 523, 538, 704. Outer shelf and slope facies: CSUN locality 482. Shallow-marine (regressive) facies: CSUN localities 512c, 512d.

Remarks. *E. hannibali* is one of the most common species of the Llajas Formation. It occurs in all the marine facies of the formation and is particularly characteristic of the shallow-marine (transgressive) facies. According to Marincovich (1977:231), this species may occur in prolific numbers. This is especially true for the “Stewart bed” in the vicinity of localities 374 and 444. There, *E. hannibali* is the most com-

mon megafossil with nearly complete growth series present also.

Genus *Tejonia* Hanna and Hertlein, 1943

Type Species. By monotypy, *Natica alveata* Conrad, 1855, not Troschel, 1852.

Tejonia moragai (Stewart, 1927)

Figure 7d

Natica alveata Conrad, 1855:10; 1857:321, pl. 2, figs. 8, 8a. Not *Natica alveata* Troschel, 1852:159, pl. 5, fig. 3.

Amauropsis alveata (Conrad). Gabb, 1864:110, pl. 19, fig. 59; pl. 21, fig. 111. Dickerson, 1916:pl. 38, fig. 7. Anderson and Hanna, 1925:119–120, pl. 6, fig. 2; pl. 7, fig. 1; pl. 15, fig. 17.

Amauropsis alveatus (Conrad). Arnold, 1907:pl. 39, fig. 8.

Amaurellina moragai Stewart, 1927:334–336, pl. 28, fig. 3 [new name for *Natica alveata* Conrad, 1855, preoccupied]. Clark, 1929:pl. 14, figs. 3, 9. Kleinpell and Weaver, 1963: 188, pl. 25, figs. 1–2.

Amaurellina moragai lajollaensis Stewart, 1927:336, pl. 28, fig. 2.

Amaurellina hendoni Turner, 1938:86–87, pl. 20, figs. 7, 8, 11. Vokes, 1939:173, pl. 22, figs. 7, 10. Weaver, 1943:345, pl. 70, figs. 12–13, 16–17.

Tejonia lajollaensis (Stewart). Hanna and Hertlein, 1943: 172, fig. 62–30. Givens, 1974:74, pl. 8, fig. 5.

Tejonia moragai (Stewart). Givens, 1974:74, pl. 8, fig. 8. Marincovich, 1977:232–236, pl. 19, figs. 6–12. Squires, 1977:table 1. Givens and Kennedy, 1979:tables 1, 3–4.

Primary Type Material. Holotype unknown for *Natica alveata* Conrad (USNM collection?), Tejon Formation, Grapevine Canyon, Tejon quadrangle, Kern County, California. UCMP “holotype” 31387 of *Amaurellina moragai* Stewart, Tejon Formation, UCMP locality 7200. See Marincovich, 1977:235 for a discussion of Stewart’s (1927) “holotype.”

Molluscan Stage Range. “Domengine” through “Tejon.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 467. Shallow-marine (regressive) facies: CSUN locality 489.

Remarks. At locality 373, *T. moragai* is fairly common and occurs as a growth series. Some specimens have their protoconchs present. Elsewhere, only single specimens were found. This species is characterized by its strongly tabulate adult whorls.

Genus *Pachycrommium* Woodring, 1928

Type Species. By original designation, *Amaura guppyi* Gabb, 1873.

Pachycrommium clarki (Stewart, 1927)

Figure 7e

Amauropsis alveata (Conrad). Arnold, 1910:pl. 4, fig. 21. Waring, 1917:pl. 15, fig. 25. Dickerson, 1915:pl. 5, fig. 9

[not *Natica alveata* Conrad, 1855 = *Tejonia moragai* (Stewart, 1927), treated herein].

Amaurellina (Euspirocrommium) clarki Stewart, 1927:336–339, pl. 26, figs. 8–9 [new name, in part, for *Amauropsis alveata* (Conrad, 1855), preoccupied]. Clark, 1929:pl. 11, fig. 10. Turner, 1938:86, pl. 20, fig. 3. Weaver, 1943:345, pl. 70, figs. 10, 18. Kleinpell and Weaver, 1963:188, pl. 27, fig. 15.

Amaurellina clarki Stewart. Gardner and Bowles, 1934:246, figs. 6, 8.

Amaurellina? multiangulata Vokes, 1939:174, pl. 22, figs. 2, 8, 13.

Pachycrommium? clarki (Stewart). Vokes, 1939:175, pl. 22, figs. 11, 30. Givens, 1974:73, pl. 8, figs. 6, 10. Squires, 1977:table 1.

Amaurellina (Euspirocrommium?) clarki Stewart. Stewart, 1946:pl. 11, fig. 3.

Pachycrommium clarki (Stewart). Marincovich, 1977:238–241, pl. 20, figs. 4–10. Squires, 1983b:fig. 9d.

Primary Type Material. UCMP holotype 31385, UCMP paratype 31386 of *Amaurellina (Euspirocrommium) clarki* Stewart, Lajas Formation, UCMP locality 7004 = CSUN locality 374.

Molluscan Stage Range. “Capay” through “Tejon.”

Geographic Distribution. San Diego, California through northern Washington.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 452, 469a, 702, 703. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 373, 374, 444, 447, 455, 457, 466, 469e, 471e, 479, 484, 486, 488, 491, 492, 493, 494, 498, 500, 505, 506, 507, 508, 513, 514, 518, 528, 537, 538. Outer shelf and slope facies: CSUN locality 482. Outer shelf and slope channel facies: CSUN locality 541.

Remarks. This species is especially abundant at localities 371 and 374, and at both localities it occurs as a growth series.

Subfamily Polinicinae Finlay and Marwick, 1937

Genus *Polinices* Montfort, 1810

Type Species. By original designation, *Polinices albus* Montfort, 1810.

Subgenus *Euspira* Agassiz in J. Sowerby, 1838b

Type Species. By subsequent designation (Harris, 1897), *Ampullaria sigaretina* Lamarck, 1804.

Polinices (Euspira) nuciformis (Gabb, 1864) Figure 7f

Lunatia nuciformis Gabb, 1864:107, pl. 28, fig. 218. Dickerson, 1916:pl. 39, fig. 4.

Lunatia cowlitzensis Dickerson, 1915:57, pl. 4, figs. 12a–b.

Natica nuciformis (Gabb). Anderson and Hanna, 1925:116, pl. 10, fig. 8.

Polinices (Euspira) nuciformis (Gabb). Clark and Woodford, 1927: 121, pl. 21, figs. 16–17. Turner, 1938:88, pl. 20, figs. 4–5. Clark, 1938:703–704, pl. 4, figs. 26, 31. Vokes, 1939: 168, pl. 21, figs. 12–14. Weaver, 1943:342–343, pl. 70, figs. 1–2; pl. 103, fig. 2.

Euspira nuciformis (Gabb). Stewart, 1927:323–324, pl. 30, fig. 16; 1946:pl. 11, fig. 16. Weaver, 1953:29. Givens, 1974: 77, pl. 7, fig. 14. Squires, 1977:table 1.

Polinices (Euspira) nuciformis var. *cowlitzensis* (Dickerson). Weaver, 1943:343, pl. 69, figs. 10–11, 13–19.

Polinices (Euspira) nuciformis (Gabb). Marincovich, 1977: 281–285, pl. 26, figs. 6–9.

Primary Type Material. ANSP lectotype 4213, ANSP paralectotypes 4213 (two specimens), Tejon Formation, Live Oak Canyon, Kern County, California.

Molluscan Stage Range. Upper Paleocene through “Tejon.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only three specimens were found in the Lajas Formation.

Genus *Neverita* Risso, 1826

Type Species. By monotypy, *Neverita josephina* Risso, 1826.

Subgenus *Neverita* s.s.

Neverita (Neverita) globosa Gabb, 1869

Figure 7g

Neverita globosa Gabb, 1869:161, pl. 27, fig. 39. Dickerson, 1916:510, pl. 39, figs. 5a–b. Stewart, 1927:326–327, pl. 28, fig. 6. Clark and Woodford, 1927:121–122, pl. 22, figs. 5–10. Turner, 1938:89, pl. 19, figs. 6–7, 13–15. Vokes, 1939: 169, pl. 21, figs. 9, 15–19. Givens and Kennedy, 1979: tables 1–3.

Neverita weaveri Dickerson, 1915:57, pl. 4, figs. 10a–b.

Neverita nomlandi Dickerson, 1917:173–174, pl. 30, figs. 2a–b.

Polinices weaveri (Dickerson). Turner, 1938:86, pl. 20, figs. 14, 16.

Neverita globosa reefensis Vokes, 1939:169, pl. 21, figs. 24–25.

Polinices (Neverita) weaveri (Dickerson). Weaver, 1943:340, pl. 68, figs. 16–17; pl. 69, fig. 3.

Polinices (Neverita) globosa (Gabb). Weaver, 1943:339, pl. 68, figs. 21, 24; pl. 69, figs. 5–6; pl. 100, fig. 29.

Polinices (Neverita) nomlandi (Dickerson). Weaver, 1943: 340, pl. 69, figs. 8, 9, 12.

Neverita (Neverita) globosa Gabb. Givens, 1974:76. Marincovich, 1977:312–316, pl. 28, figs. 10–15; pl. 29, figs. 1–3.

Neverita (Glossaulax?) globosa Gabb. Givens and Kennedy, 1976:965–966, pl. 2, figs. 5–14, 16, 18–19.

Neverita globosa Gabb. Givens and Kennedy, 1979:tables 1–3.

Primary Type Material. MCZ holotype 27859, Domengine? Formation, 16 km west of Griswold's, on the road from San Juan to New Idria, and southeast of the "Sheep Well," T 15 S, R 9 E, Priest Valley quadrangle, San Benito County, California.

Molluscan Stage Range. "Meganos" through upper Eocene.

Geographic Distribution. San Diego, California through western Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 704.

Remarks. Only three specimens were found in the Llajas Formation.

Subfamily Sininae Wenz, 1941

Genus *Sinum* Röding, 1798

Type Species. By subsequent designation (Dall, 1915), *Helix halioidea* Linné, 1758.

Sinum obliquum (Gabb, 1864)

Figure 7h

Naticina obliqua Gabb, 1864:109, pl. 21, fig. 112. Dickerson, 1915:pl. 5, figs. 5a–b.

Sinum occidentis Weaver and Palmer, 1922:32–33, pl. 11, figs. 8, 26. Weaver, 1943:351, pl. 71, fig. 15.

Sinum coryliforme Anderson and Hanna, 1925:120, pl. 9, fig. 10; pl. 10, fig. 15; pl. 15, fig. 8.

Sinum obliquum (Gabb). Stewart, 1927:327, pl. 30, fig. 7a. Clark, 1938:704, pl. 3, figs. 32, 37. Weaver, 1943:350–351, pl. 71, fig. 13; pl. 103, fig. 6. Hickman, 1969:85–88, pl. 11, figs. 9–10. Marinovich, 1977:347–350, pl. 33, figs. 1–12. Squires, 1977:table 1. Givens and Kennedy, 1979:table 4.

Primary Type Material. ANSP lectotype 4215, ANSP paralectotypes 4215 (seven specimens), Tejon Formation, Fort Tejon area, Kern County, California.

Molluscan Stage Range. "Capay" through lower Oligocene.

Geographic Distribution. San Diego, California through southwestern Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 539.

Remarks. *S. obliquum* is most common at locality 371 where it is well preserved and occurs as a growth series. At locality 539, only a single specimen was found.

Subfamily Naticinae Forbes, 1838

Genus *Natica* Scopoli, 1777

Type Species. By subsequent designation (Anton, 1839), *Nerita vitellus* Linné, 1758.

Subgenus *Naticarius* Duméril, 1806

Type Species. By monotypy, *Nerita canrena* Linné, 1758.

Natica (*Naticarius*) aff.

N. (N.) uvasana Gabb, 1864

Figure 7i

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 545. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 486.

Remarks. This taxon is most common at locality 371 where 32 specimens make up a growth series. The largest specimen is 18 mm in height. Elsewhere, only a few specimens were found.

The Llajas specimens agree with the description of *N. (N.) uvasana* given by Marinovich (1977:390) in possessing irregularly spaced collabral wrinkles immediately below the suture, an open umbilicus, and a robust umbilical callus and funicle. The Llajas specimens differ in that they lack a parietal callus.

Superfamily Tonnacea

Family Cassididae Latreille, 1825

Genus *Galeodea* Link, 1807

Type Species. By monotypy, *Buccinum echinophorum* Linné, 1758.

Subgenus *Caliagaleodea* Clark, 1942

Type Species. By original designation, *Caliagaleodea californica* Clark, 1942.

Galeodea (*Caliagaleodea*) *californica*

Clark, 1942

Figure 7j

Galeodea (*Caliagaleodea*) *californica* Clark, 1942:118–119, pl. 19, figs. 15–19.

Galeodea californica Clark. Givens and Kennedy, 1979:table 1.

Primary Type Material. UCMP holotype 34376, UCMP paratype 34377, Llajas Formation, UCMP locality 7004 = CSUN locality 374.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego through Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 444, 445, 447, 458.

Remarks. Nearly all the specimens of this species were found at the type locality. The 14 specimens at locality 374 make up a nearly complete growth series, but most occur as internal molds. A few other specimens were found elsewhere in the "Stewart bed" in the vicinity of locality 374.

Subgenus *Gomphopages* Gardner, 1939

Type Species. By original designation, *Galeodea turneri* Gardner, 1939.

Galeodea (Gomphopages) susanae Schenck, 1926

Figure 7k

Galeodea susanae Schenck, 1926:85, pl. 15, figs. 3–7. Turner, 1938:92, pl. 18, fig. 18. Weaver, 1943:402–403, pl. 78, figs. 2–3.

Galeodea (Gomphopages) susanae Schenck. Durham, 1942:184. Givens, 1974:78.

Primary Type Material. CAS holotype 1753, CAS paratype 1754, Llajas Formation, CAS locality 372; CAS paratype 1755, Llajas Formation, CAS locality 364; CAS paratype 1756, near Roseburg, Oregon.

Molluscan Stage Range. “Domengine,” “Transition”?

Geographic Distribution. Simi Valley, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371.

Remarks. The 16 specimens from locality 371 make up a growth series, and they are extremely well preserved. There is excellent preservation of spines and, in a few cases, the long anterior canal. The largest specimen is 53 mm in height.

Genus *Phalium* Link, 1807

Type Species. By subsequent designation (Dall, 1909), *Buccinum glaucum* Linné, 1758.

Subgenus *Semicassis* Mörch, 1852

Type Species. By subsequent designation (Harris, 1897), *Cassiss japonica*.

Phalium (Semicassis) tuberculiformis
(Hanna, 1924)

Figure 7l

Morio (Sconsia) tuberculatus Gabb, 1864:104, pl. 19, fig. 57. Arnold, 1907:pl. 39, fig. 9.

Not *Cassidaria tuberculata* Risso, 1826:186.

Morio tuberculatus Gabb. Dickerson, 1913:264.

Galeodea tuberculata (Gabb). Dickerson, 1916:pl. 42, fig. 2. *Galeodea (Morio) tuberculata* (Gabb). Waring, 1917:pl. 15, fig. 17.

Galeodea tuberculiformis Hanna, 1924:167 [new name for *Morio (Sconsia) tuberculatus* Gabb, 1864, preoccupied]. Schenck, 1926:83–84, pl. 14, figs. 12–16. Stewart, 1927:380–381, pl. 28, fig. 11. Vokes, 1939:149–150, pl. 19, figs. 19, 21, 23–27.

Coalingodea tuberculiformis (Hanna). Durham, 1942:186, pl. 29, figs. 5, 9. Givens, 1974:78–79, pl. 8, fig. 7. Squires, 1977:table 1.

Cassiss (Coalingodea) tuberculata (Gabb). Abbott, 1968b:59–60, pl. 34.

Phalium (Semicassis) tuberculiformis (Hanna). Givens and Kennedy, 1979:82, 95, tables 1, 3.

Primary Type Material. ANSP lectotype 4343 of *Morio (Sconsia) tuberculatus* Gabb and *Galeodea tuberculiformis* Hanna, Tejon? Formation, Martinez, California.

Molluscan Stage Range. “Capay”?, “Domengine” through “Transition.”

Geographic Distribution. San Diego, California through northwestern Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 373, 374, 440, 444, 445, 455, 458, 471b, 480, 488, 494, 514, 537. Outer shelf and slope channel facies: CSUN locality 541. Shallow-marine (regressive) facies: CSUN localities 462, 512d.

Remarks. This taxon is most common and best preserved at localities 371 and 374, where it occurs in growth series. The beaded appearance of the whorls and the toothed outer lip are well preserved.

Dickerson (1913) reported this species from “Capay”-age strata in central California, but he gave no specific locality information nor did he figure the species. For these reasons, the “Capay”-age occurrence is uncertain.

The presence of *P. (S.) tuberculiformis* in the Llajas Formation is one of the earliest occurrences of *Phalium* on the West Coast. It is also known from similar age strata in San Diego County (Givens and Kennedy, 1979).

Family Cymatiidae Iredale, 1913

Genus *Cymatium* Röding, 1798

Type Species. By subsequent designation (Dall, 1904), *Murex femorale* Linné, 1758.

Subgenus *Septa* Perry, 1810

Type Species. By monotypy, *Septa scarlatina* Perry, 1810 (= *Murex rubecula* Linné, 1758).

Cymatium (Septa) janetae Squires, 1983a

Figure 7m

Cymatium (Septa) janetae Squires, 1983a:355–357, figs. 2a–d.

Primary Type Material. UCLA holotype 59191, Llajas Formation, CSUN locality 444; UCLA paratype 59192, Llajas Formation, CSUN locality 445; UCLA paratype 59193, Llajas Formation, CSUN locality 371.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 374, 444, 498.

Remarks. Only juvenile specimens occur at localities 371 and 498. Only adult specimens occur in the “Stewart bed” at and near localities 374 and 444. The figured specimen (Fig. 7m) is the holotype. *C. (S.) janetae* is, at present, the earliest species worldwide referable to *Septa* (Squires, 1983a).

Genus *Ranella* Lamarck, 1816

Type Species. By subsequent designation (Children, 1823), *Ranella gigantea* Lamarck, 1816 [= *Murex olearium* Linné, 1758].

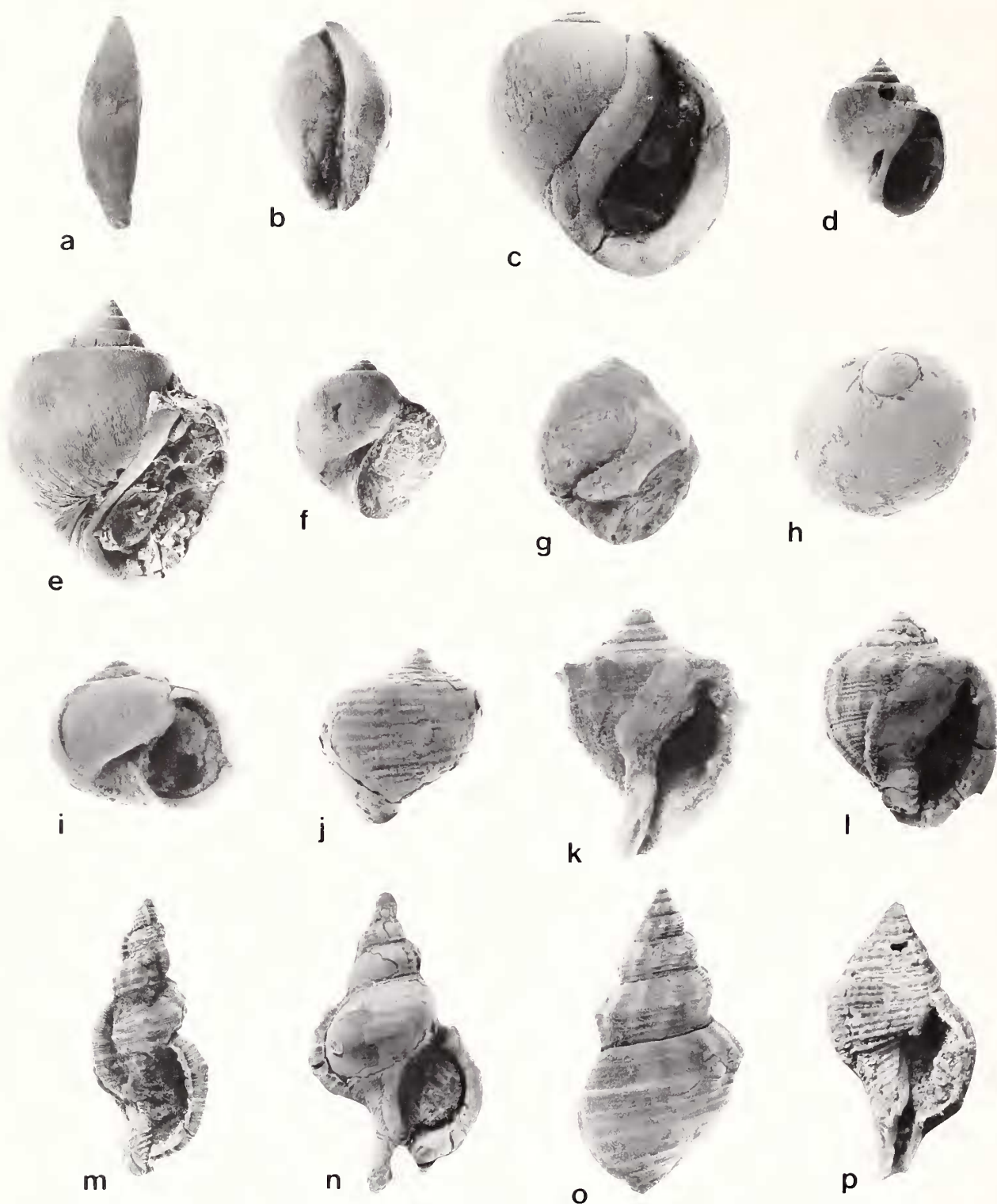


Figure 7. Llajas Formation gastropods (continued). Unless otherwise indicated, views are apertural. **a.** *Paraseraphs erraticus* (Cooper, 1894), abapertural view, LACMIP hypotype 6522, CSUN loc. 371, $\times 1$. **b.** *Cypraea castacensis* Stewart, 1927, LACMIP hypotype 6523, CSUN loc. 374, $\times 1.25$. **c.** *Eocerrina hannibali* (Dickerson, 1914), hypotype LACMIP 6524, CSUN loc. 374, $\times 1$. **d.** *Tejonina moragai* (Stewart, 1927), LACMIP hypotype 6525, CSUN loc. 467, $\times 1$. **e.** *Pachycrommium clarki* (Stewart, 1927), LACMIP hypotype 6526, CSUN loc. 371, $\times 1$. **f.** *Polinices (Euspira) nuciformis* (Gabb, 1864), UCLA hypotype 59276, CSUN loc. 374, $\times 1$. **g.** *Neverita (Neverita) globosa* Gabb, 1869, LACMIP hypotype 6527, CSUN loc. 704, $\times 1.5$. **h.** *Sinum obliquum* (Gabb, 1864), side view, LACMIP hypotype 6528, CSUN loc. 371, $\times 2$. **i.** *Natica*

Ranella katherineae Squires, 1983a

Figure 7n

"*Ranella*" sp. Smith, 1970:523.

Ranella katherineae Squires, 1983a:357–359, figs. 2c–g.

Primary Type Material. UCLA holotype 45969, Lajas Formation, CSUN locality 374.

Molluscan Stage Range. "Domenginee."

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only a single, nearly complete adult specimen was found in the Lajas Formation. This specimen is the holotype and the figured specimen (Fig. 7n). *R. katherineae* is one of the earliest West Coast species of *Ranella* s.s. (Squires, 1983a).

Family Bursidae Thiele, 1925

Genus *Olequahia* Stewart, 1927

Type Species. By original designation, *Cassidaria wasingtoniana* Weaver, 1912.

Olequahia domenginica (Vokes, 1939)

Figure 7o

Ranella domenginica Vokes, 1939:147–148, pl. 19, figs. 6, 20.

Olequahia hornii domenginica (Vokes). Stewart, 1946: table 1.

Olequahia domenginica (Vokes). Givens, 1974:80, pl. 9, figs. 4–5. Givens and Kennedy, 1979:table 1.

Primary Type Material. UCMP syntypes 15803 and 15804, Domengine Formation, UCMP locality 672.

Molluscan Stage Range. "Domengine Stage."

Geographic Distribution. San Diego through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 374, 444, 445, 471d, 494.

Remarks. Specimens are most common in the "Stewart bed" at locality 374 where they form a growth series.

Vokes (1939:147–148) used non-type, supplementary specimens from the vicinity of locality 374 to augment his description of this taxon.

Genus *Ranellina* Conrad, 1865

Type Species. By original designation, *Ranellina maclurii* Conrad, 1865.

Ranellina pilsbryi Stewart, 1927

Figure 7p

Not *Clavatula?* *californica* Conrad, 1855:11; 1857:322, pl. 2, fig. 11.

Fusus californicus (Conrad). Gabb, 1864:85–86, pl. 28, figs. 205–205a.

Nyctilochus hornii (Gabb). Dickerson, 1915:pl. 7, fig. 8. Dickerson, 1916:pl. 42, fig. 3.

Clavilithes californicus (Conrad). Anderson and Hanna, 1925: 63–64, pl. 13, figs. 1–2.

Ranellina pilsbryi Stewart, 1927:384–385, pl. 30, figs. 8–9 [new name for *Fusus californicus* (Conrad) Gabb, 1864, misidentified]. Turner, 1938:91, pl. 16, fig. 3. Vokes, 1939: 148, pl. 19, figs. 10, 17. Weaver, 1943:417, pl. 82, fig. 7. Givens, 1974:80, pl. 9, fig. 12. Givens and Kennedy, 1979: tables 1, 4.

Primary Type Material. UCMP holotype 31382, UCMP paratype 31383 of *Ranellina pilsbryi* Stewart, Tejon Formation, UCMP locality 7182.

Molluscan Stage Range. "Domengine" through "Tejon."

Geographic Distribution. San Diego, California to southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 486, 498.

Remarks. This species is most common at locality 371 where seven specimens were found.

Smith (1975:table 1) reported "*Ranellina*" sp. aff. *R. pilsbryi* from "Martinez"-age strata of central California.

Family Ficidae Conrad, 1867

Genus *Ficopsis* Conrad, 1866

Type Species. By subsequent designation (Stewart, 1927), *Hemifusus remondii* Gabb, 1864.

Ficopsis cooperiana Stewart, 1927

Figure 8a

Fusus (*Hemifusus*) *cooperii* Gabb, 1864:86, pl. 28, fig. 207. Not *Fusus cooperi* Conrad, 1834:148.

Ficopsis cooperii (Gabb). Dickerson, 1915:61–62, pl. 6, fig. 11; 1916:492–493, pl. 37, fig. 7. Clark, 1929:pl. 9, fig. 13.

Ficopsis cooperiana Stewart, 1927:378–379 [new name for *Fusus* (*Hemifusus*) *cooperii* Gabb, 1864, preoccupied]. Clark, 1929:pl. 9, fig. 13. Givens, 1974:81, pl. 9, figs. 7, 9. Givens and Kennedy, 1979:87, table 3.

Primary Type Material. UCMP holotype 11691 of *Fusus* (*Hemifusus*) *cooperii* Gabb and *Ficopsis cooperiana* Stewart, Eocene strata, UCMP locality 2226.

←
(*Naticarius*) aff. *N. (N.) uvasana* Gabb, 1864, LACMIP hypotype 6529, CSUN loc. 371, ×2. j. *Galeodea* (*Caliagaleodea*) *californica* Clark, 1942, internal mold, abapertural view, LACMIP topotype and hypotype 6530, CSUN loc. 374, ×1. k. *Galeodea* (*Gomphopages*) *susanae* Schenck, 1926, LACMIP hypotype 6531, CSUN loc. 371, ×1.5. l. *Phalium* (*Semicassis*) *tuberculiformis* (Hanna, 1924), LACMIP hypotype 6532, CSUN loc. 371, ×1. m. *Cymatium* (*Septa*) *janetae* Squires, 1983a, UCLA holotype 59191, CSUN loc. 444, ×1. n. *Ranella katherineae* Squires, 1983a, UCLA holotype 45969, CSUN loc. 374, ×0.5. o. *Olequahia domenginica* (Vokes, 1939), LACMIP hypotype 6533, CSUN loc. 374, ×1. p. *Ranellina pilsbryi* Stewart, 1927, LACMIP hypotype 6534, CSUN loc. 371, ×2.5.

Molluscan Stage Range. "Domengine" through "Transition."

Geographic Distribution. San Diego through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only a few specimens were found in the Llajas Formation.

Ficopsis remondii crescentensis
Weaver and Palmer, 1922

Figure 8b

Ficopsis angulatus Weaver, 1905:119, pl. 13, fig. 5.

Not *Pyrula angulata* Edwards, 1866:pl. 4.

Ficopsis remondii (Gabb) var. *crescentensis* Weaver and Palmer, 1922:39–40, pl. 11, fig. 14 [new name for *Ficopsis angulatus* Weaver, 1905, preoccupied]. Stewart, 1930:40–41. Turner, 1938:93, pl. 15, fig. 19. Weaver, 1943:399, pl. 77, fig. 10.

Ficopsis remondii crescentensis Weaver and Palmer. Vokes, 1939:152–153. Givens, 1974:82, pl. 9, fig. 11. Squires, 1977:table 1. Givens and Kennedy, 1979:87, tables 1, 3.

Ficopsis crescentensis Weaver and Palmer. Stewart, 1946:pl. 11, fig. 17.

Primary Type Material. UCMP holotype 11887 of *Ficopsis angulatus* Weaver, Eocene strata, UCMP locality 337. UW holotype 205 (CAS 7616) of *Ficopsis remondii crescentensis* Weaver and Palmer, Crescent? Formation, UW locality 358.

Molluscan Stage Range. "Capay" through "Transition."

Geographic Distribution. San Diego, California through northwestern Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 374, 477, 479, 486.

Remarks. Specimens are most common at locality 371 although the largest specimens occur at locality 374. This taxon is characterized by the tri-carination of the body whorl and the cancellate sculpture.

Order Neogastropoda

Superfamily Muricea

Family Muricidae da Costa, 1776

Subfamily Muricinae da Costa, 1776

Genus *Laevityphis* Cossmann, 1903

Type Species. By original designation, *Typhis coronarius* Deshayes, 1865.

Subgenus *Laevityphis* s.s.

Laevityphis (Laevityphis) antiquus
(Gabb, 1864)

Figure 8c

Typhis antiquus Gabb, 1864:82, pl. 18, fig. 31. Stewart, 1927:387–388, pl. 27, figs. 7–8.

Laevityphis (Laevityphis) antiquus (Gabb). Keen, 1944:58, 63. Givens, 1974:82.

Laevityphis antiquus (Gabb). Givens and Kennedy, 1979:table 3.

Primary Type Material. ANSP lectotype 4335, Tejon? Formation, Martinez, California.

Molluscan Stage Range. "Domengine" through "Tejon."

Geographic Distribution. San Diego through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371.

Remarks. Only a single specimen was found in the Llajas Formation.

Family Buccinidae Rafinesque, 1815

Genus *Ancistrolepis* Dall, 1895

Type Species. By original designation, *Chrysodomus eucosmius* Dall, 1891.

Ancistrolepis? carolineae n. sp.

Figures 8d–e

Diagnosis. Bucciniform shell with two spiral ribs on spire and about six spiral ribs on body whorl, interspaces characteristically concave with numerous fine lirae. Due to the fact that the canal area has been broken off on each of the Llajas specimens, positive generic assignment cannot be made.

Ancistrolepis? carolineae n. sp. is very similar to *A. clarki* Tegland (1933:131–132, pl. 12, fig. 14) and *A. clarki* variety? Tegland (1933:132, pl. 12, figs. 15–17) from the Oligocene Blakeley Formation, northwestern Washington. *A.? carolineae* differs from *A. clarki* and *A. clarki* var.? in the following features: less convex whorls, narrower and shorter spire, equally spaced primary spiral ribs on the spire, less inflated spiral ribs, and smaller shell size. Unfortunately, the anterior canal area is missing in the Llajas specimens and comparison to the ornamented canal areas of *A. clarki* and *A. clarki* var.? cannot be made. *A. clarki* and *A. clarki* var.? differ from each other only in the nature of the canal area ornamentation.

Description. Medium shell, bucciniform, with five or six angulate whorls. Suture moderately impressed. Protoconch smooth with low, rounded whorls and shallow sutures.

Spire whorls with two very prominent, primary spiral ribs that divide the whorls into three equal concave areas covered with numerous fine lirae. Body whorl with five to six primary spiral ribs, interspaces concave and covered with numerous fine lirae.

Columella smooth and twisted. Aperture straight. Thickened outer lip. Anterior canal area missing. Dimensions of largest specimen (Figs. 8d–e): height (incomplete) 32 mm, body whorl width 20 mm.

Primary Type Material. UCLA holotype 59401, UCLA paratypes 59402 (three specimens), Llajas Formation, CSUN locality 374.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Specimens of this new species were found only at CSUN locality 374 ("Stewart bed"). A total of 12 specimens was found, and preservation is mostly as internal molds. A few specimens (i.e., the primary type material) have portions of the original shell material.

Ancistrolepis Dall is differentiated from *Chrysodomus* in three respects; namely, a shorter canal, a degenerate radula, and in the nature of the operculum. Although only the canal feature can be used in fossil material, Tegland (1933) considered that the outline of the shell and detail of sculpturing of *A. clarki* was so close to the Recent species, *Ancistrolepis eucosimus* Dall (1895:709, pl. 29, fig. 7), the type species of the genus, that reference to that genus rather than *Chrysodomus* was warranted. The Llajas specimens of *A. carolineae* n. sp. are very similar to those of *A. clarki* and *A. clarki* var.?, and they are not similar to West Coast Paleogene species of *Chrysodomus* in terms of sculpture.

If *A. carolineae* does belong to *Ancistrolepis*, it would extend the earliest occurrence of this genus to the early middle Eocene, and *A. carolineae* would be the oldest known species referable to this genus. It would be the first occurrence of this genus in California.

Etymology. The species is named for Caroline Squires.

Superfamily Buccinacea

Family Nassariidae Iredale, 1916

Genus *Molopophorus* Gabb, 1869

Type Species. By monotypy, *Bullia* (*Molopophorus*) *striata* Gabb, 1869.

Molopophorus cretaceus (Gabb, 1864)

Figure 8f

Nassa cretacea Gabb, 1864:97, pl. 18, fig. 49.

Molopophorus cretaceus (Gabb). Stewart, 1927:391–392, pl. 28, fig. 9. Vokes, 1939:141–142, pl. 19, fig. 4.

Primary Type Material. ANSP lectotype 4197, Domengine Formation, Bulls Head Point, near Martinez, California.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 467.

Remarks. Only two specimens were found in the Llajas Formation, and the apertures are covered or smashed.

Family Fasciolaridae Gray, 1853

Genus *Clavilithes* Swainson, 1840

Type Species. By subsequent designation (Grabau, 1904), *Fusus parisiensis* Mayer-Eymar, 1877 [= *Fusus longaevus* Lamarck, 1803, not Solander, 1766].

Clavilithes tabulatus (Dickerson, 1913)

Figure 8g

Clavella tabulata Dickerson, 1913:283, pl. 12, fig. 7.

Clavilithes tabulatus (Dickerson). Clark and Vokes, 1936: 874, pl. 1, fig. 3 (holotype refigured). Givens, 1974:85, pl. 10, figs. 4–5.

Clavilithes cf. *C. tabulatus* (Dickerson). Crowell and Susuki, 1959:588–589, pl. 2, figs. 6–7.

Primary Type Material. UCMP holotype 11753, Capay Formation, UCMP locality 1853.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Orocopia Mountains, southern California through central California.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 703. Shallow-marine (transgressive) facies: CSUN localities 371, 374, 704.

Remarks. Only two specimens were found. The presence of *C. tabulatus* in the middle part of the Llajas extends the molluscan stage range of this taxon into the "Domengine Stage." Previously it had been reported as confined to the "Capay Stage" (Clark and Vokes, 1936; Crowell and Susuki, 1959; Givens, 1974).

Clavilithes n. sp. A Clark and Vokes, 1936

Figure 8h

Clavilithes n. sp. Clark and Vokes, 1936:874, pl. 1, fig. 1. Givens and Kennedy, 1976:973, pl. 4, figs. 9, 12.

Type Material. UCMP hypotype 15468, Llajas Formation, UCMP locality 3296 (Clark and Vokes, 1936). UCR hypotype 4865/13, middle Eocene strata, UCR locality 4865 (Givens and Kennedy, 1976). LACMIP hypotype 6540, Llajas Formation, CSUN locality 704.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego through Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 704.

Remarks. Two specimens of this taxon were found with *C. tabulatus* at CSUN locality 704. *C. n. sp. A* is characterized by the presence of nodes on the spire. It is not named at this time pending further taxonomic research by Jack Mount, Rutgers University.

Clavilithes n. sp. B Squires, 1983a

Figure 8i

Clavilithes n. sp. Squires, 1983a:359, figs. 2h–i.

Type Material. UCLA hypotype 59194, Llajas Formation, CSUN locality 445; UCLA hypotype 59195, Llajas Formation, CSUN locality 444.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 444, 445.

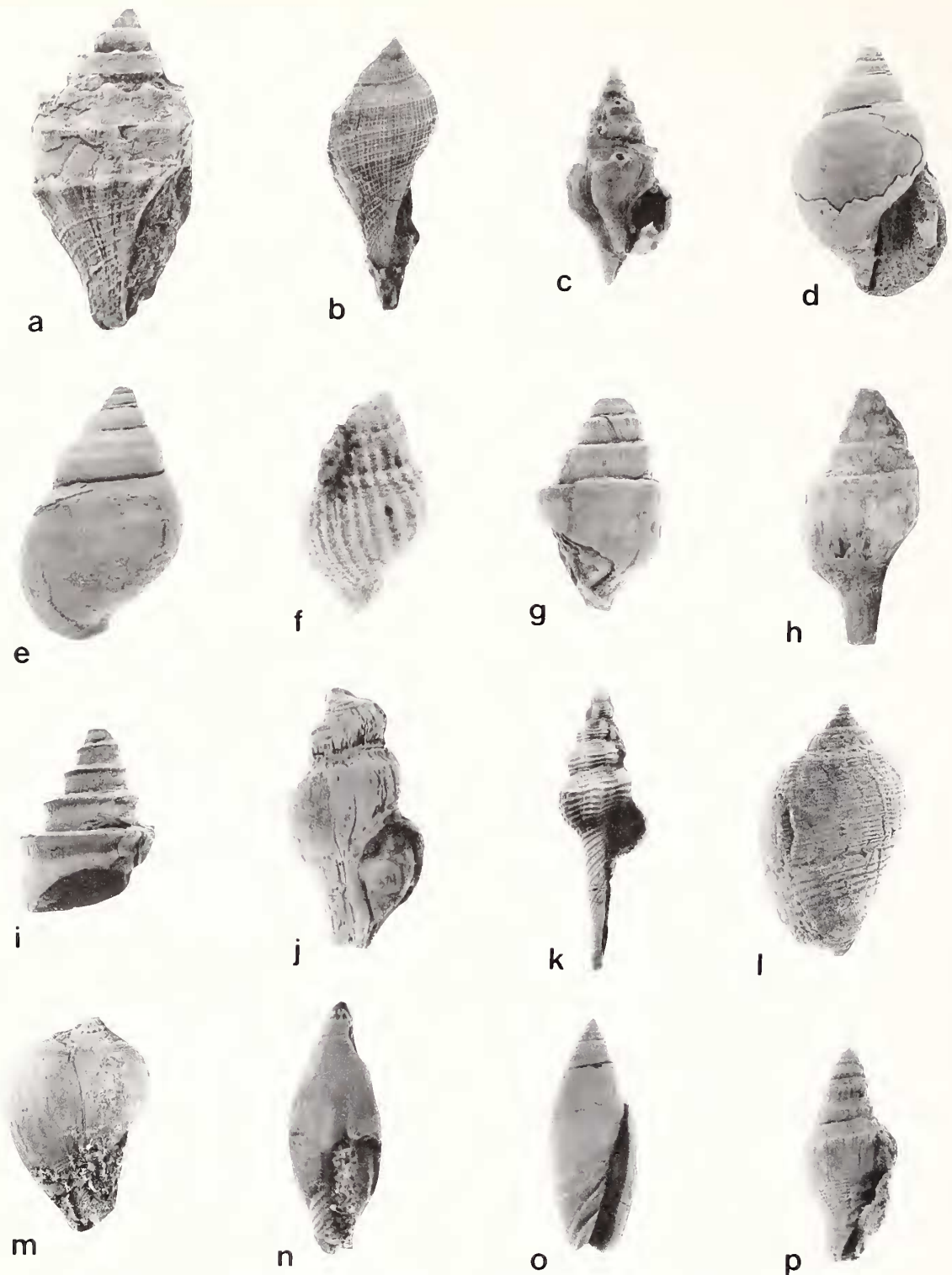


Figure 8. Lajas Formation gastropods (continued). Unless otherwise indicated, views are apertural. **a.** *Ficopsis cooperiana* Stewart, 1927, side view, UCLA hypotype 59277, CSUN loc. 374, $\times 2$. **b.** *Ficopsis remondii crescentensis* Weaver and Palmer, 1922, LACMIP hypotype 6535, CSUN loc. 374, $\times 1$. **c.** *Laevityphis* (*Laevityphis*) *antiquus* (Gabb, 1864), LACMIP hypotype 6536, CSUN loc. 371, $\times 2$. **d and e.** *Ancistrolepis? carolineae* n. sp. All parts UCLA holotype 59401, CSUN loc. 374, $\times 1.25$. **e.** abapertural view. **f.** *Molopophorus cretaceus* (Gabb, 1864), abapertural view, LACMIP hypotype 6537, CSUN loc. 467, $\times 7$. **g.** *Clavilithes tabulatus* (Dickerson, 1913), LACMIP hypotype 6538, CSUN loc. 371, $\times 0.5$. **h.** *Clavilithes* n. sp. A Clark and Vokes, 1936, LACMIP hypotype 6539, CSUN loc. 704, $\times 1.25$. **i.** *Clavilithes* n. sp. B

Remarks. This taxon occurs with *C. tabulatus* at CSUN locality 374. *C. n. sp. B* differs from *C. n. sp. A* in the presence of an overhanging carina and in the lack of nodes on the spire. *C. n. sp. B* is not named at this time pending further taxonomic research by Jack Mount, Rutgers University.

Subfamily Fusininae Swainson, 1840

Genus *Fusinus* Rafinesque, 1815

Type Species. By monotypy, *Murex colus* Linné, 1758.

Fusinus teglandae Hanna, 1927

Figure 8j

Fusinus teglandi Hanna, 1927:315, pl. 51, fig. 9.

Fusinus teglandae Hanna. Givens, 1974:85, pl. 10, figs. 6-7.

Primary Type Material. UCMP holotype 31124, Ardath Shale, UCMP locality 5062.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego through Pine Mountain, southern California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only three poorly preserved specimens were found in the Llajas Formation. The upper spire is missing in all three specimens.

Fusinus aff. *F. ucalius* Vokes, 1939

Figure 8k

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371.

Remarks. Only a single specimen was found in the Llajas Formation. It is unabraded and nearly complete, lacking only the protoconch. This specimen agrees with the description of *Fusinus ucalius* Vokes (1939:137) in having swollen collabral costae, strong spiral cords, and a long straight anterior canal. It differs in that the collabral costae are not obsolete or even subobsolete on the posterior parts of the spire whorls. These collabral costae on the Llajas specimen extend from suture to suture. According to Vokes (1939), *F. voetus* Hanna (1927:315, pl. 51, figs. 1, 2, 4) and *F. meganosensis* Clark and Woodford (1927:111, pl. 19, fig. 13) differ from *F. ucalius* in the same respect. The Llajas specimen differs from *F. voetus* by having a less elongate aperture, more swollen collabral costae, more angulate spire whorls, and only eight (rather than 15) collabral costae on the body whorl. The Llajas specimen differs from *F. meganosensis* by having much stronger collabral costae and spiral cords. In addition, on the

body whorl of *F. meganosensis*, the collabral costae tend to become obsolete posteriorly.

Superfamily Volutacea

Family Olividae Latreille, 1825

Genus *Pseudoliva* Swainson, 1840

Type Species. By original designation, *Buccinum plumbea* Chemnitz, 1780? [= *Buccinum crassa* Gmelin, 1788?].

Pseudoliva lineata Gabb, 1864

Figure 8l

Pseudoliva lineata Gabb, 1864:99, pl. 18, fig. 52. Stewart, 1927:400, pl. 28, fig. 14a. Vokes, 1939:139, pl. 18, fig. 23.

Primary Type Material. ANSP lectotype 4200, Tejon Formation s.l., northeast of Martinez, California.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley through Martinez, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 484.

Remarks. Only three specimens were found in the Llajas Formation. All show the typical *Pseudoliva* medial spiral groove. *P. lineata* is distinguished by a complete lack of nodes on the shoulder of the whorl, as noted by Turner (1938:78). As mentioned by Vokes (1939:139), Llajas Formation specimens show a spire that is somewhat higher than that of the lectotype figured by Stewart (1927, pl. 28, fig. 14a).

Genus *Strepsidura* Swainson, 1840

Type Species. By original designation, *Strepsidura costata* Swainson, 1840 [= *Fusus ficulnea* Lamarck, 1822, = *Murex turgida* Solander, 1766].

Strepsidura ficus (Gabb, 1864)

Figure 8m

Whitneya ficus Gabb, 1864:104, pl. 28, fig. 216. Dickerson, 1915:69, pl. 9, figs. 5a-d.

Strepsidura ficus (Gabb). Stewart, 1927:404-405, pl. 29, fig. 11. Kleinpell and Weaver, 1963:193, pl. 27, figs. 1-3. Givens, 1974:87, pl. 10, fig. 10.

Primary Type Material. ANSP lectotype 4331, Tejon Formation s.l., Fort Tejon area, California.

Molluscan Stage Range. Uppermost "Capay" through "Tejon."

Geographic Distribution. Simi Valley through Fort Tejon area, southern California.

Squires, 1983a, spire only, UCLA hypotype 59195, CSUN loc. 444, $\times 0.5$. j. *Fusinus teglandae* Hanna, 1927, abapertural view, LACMIP hypotype 6540, CSUN loc. 374, $\times 0.75$. k. *Fusinus* aff. *F. ucalius* Vokes, 1939, LACMIP hypotype 6541, CSUN loc. 371, $\times 1.5$. l. *Pseudoliva lineata* Gabb, 1864, LACMIP hypotype 6542, CSUN loc. 371, $\times 1.5$. m. *Strepsidura ficus* (Gabb, 1864), abapertural view, LACMIP hypotype 6543, CSUN loc. 452, $\times 1.25$. n. *Ancilla* (*Spirancilla*) *gabri* Cossmann, 1899, LACMIP hypotype 6544, CSUN loc. 489, $\times 4$. o. *Olivella mathewsonii* Gabb, 1864, LACMIP hypotype 6545, CSUN loc. 467, $\times 2.5$. p. *Proximitra?* *cretacea* (Gabb, 1864), LACMIP hypotype 6546, CSUN loc. 371, $\times 2.5$.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 452, 545, 703.

Remarks. In some of the specimens, collabral costae are fairly well developed on the earlier whorls.

The presence of *S. ficus* in the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine (transgressive) facies of the Llajas Formation extends the molluscan stage range of this species into the uppermost "Capay." Previously, the lower range limit had been reported as the "Domengine Stage" (Givens, 1974).

Subfamily Olivinae Swainson, 1840

Genus *Ancilla* Lamarck, 1799

Type Species. By monotypy, *Ancilla cinnamomea* Lamarck, 1801.

Ancilla (Spirancilla) gabbi Cossmann, 1899

Figure 8n

Ancillaria elongata Gabb, 1864:100, pl. 18, fig. 54. Hanna, 1927:323, pl. 53, figs. 9–13. Stewart, 1927:411.

Not *Ancillaria elongata* Gray, 1847:357, pl. 1, fig. 5.

Ancilla gabbi Cossmann, 1899:60 [new name for *Ancillaria elongata* Gabb, 1864, preoccupied]. Turner, 1938:72, pl. 18, fig. 6. Weaver, 1943:500, pl. 95, fig. 18.

Ancilla (Spirancilla) gabbi Cossmann. Vokes, 1939:131, pl. 18, figs. 6, 10.

Primary Type Material. Holotype lost, UCMP syntypes 12521 (two specimens) of *Ancillaria elongata* Gabb and *Ancilla gabbi* Cossmann, Ardath Shale, near San Diego, perhaps 300 m east of the summit of Soledad Mountain on the east side of the canyon in the bottom of Rose Creek.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego, California through northwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371. Shallow-marine (regressive) facies: CSUN locality 489.

Remarks. Only two specimens were found in the Llajas Formation. Both agree with Gabb's (1864) observations of callused sutures.

Genus *Olivella* Swainson, 1831

Type Species. By subsequent designation (Dall, 1909), *Olivella purpurata* Swainson, 1831 [= *Oliva dama* Mawe, 1823].

Olivella mathewsonii Gabb, 1864

Figure 8o

Olivella mathewsonii Gabb, 1864:100, pl. 18, fig. 53. Anderson and Hanna, 1925:80, pl. 8, fig. 19. Stewart, 1927:410–411, pl. 29, fig. 13. Weaver, 1943:500–501, pl. 103, fig. 7. Givens, 1974:87. Smith, 1975:469, table 1. Squires, 1977:table 1.

Primary Type Material. ANSP lectotype 4202, Tejon Formation s.l., Martinez, California.

Molluscan Stage Range. Lower "Martinez" through "Tejon."

Geographic Distribution. Simi Valley, California through northwestern Washington.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 469a. Shallow-marine (transgressive) facies: CSUN localities 467, 484, 498.

Remarks. Two specimens were found at locality 469a. At each of the other localities, only one specimen was found. The specimens agree with Gabb's (1864) observations of three columellar plicae at the anterior end of the shell. This taxon may be the same as *O. m. umpquaensis* Turner, 1938:72, pl. 18, figs. 13–14.

Family Mitridae Swainson, 1831

Subfamily Vexillinae Thiele, 1929

Genus *Proximitra* Finlay, 1927

Type Species. By original designation, *Vexillum rutidolum* Suter, 1913.

Proximitra? cretacea (Gabb, 1864)

Figure 8p

Mitra cretacea Gabb, 1864:103, pl. 28, fig. 215. Stewart, 1927:406, pl. 27, figs. 9–10.

Uromitra (?) cretacea (Gabb). Vokes, 1939:134–135, pl. 18, fig. 19.

Proximitra? cretacea (Gabb). Givens, 1974:87. Squires, 1977:table 1.

Primary Type Material. ANSP holotype 4302, Tejon Formation s.l., Martinez, California.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371.

Remarks. This taxon was found at only one locality in the Llajas Formation, but 46 specimens were collected.

Family Tudicidae Finlay and Marwick, 1937

Genus *Pseudoperissolax* Clark, 1918

Type Species. By original designation, *Busycon? blakei* Conrad, 1855.

Pseudoperissolax blakei praeblakei Vokes, 1939

Figure 9a

Not *Busycon? blakei* Conrad, 1855:11; 1857:332, pl. 2, fig. 13.

Perissolax blakei (Conrad). Gabb, 1864:92 (in part), pl. 21, fig. 110.

Pseudoperissolax blakei (Conrad) (subsp.?). Stewart, 1927:429–430, pl. 28, fig. 1.

Pseudoperissolax blakei praeblakei Vokes, 1939:145–146, pl.

19, figs. 14, 22. Givens, 1974:88, pl. 10, figs. 15–16. Smith, 1975:pl. 2, fig. 16.

Primary Type Material. UCMP holotype 15799, UCMP paratype 15800, Arroyo Hondo Formation, UCMP locality 1817.

Molluscan Stage Range. Lower “Martinez” through “Domengine.”

Geographic Distribution. San Diego?, Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only two specimens were found in the Lajas Formation. They are mostly internal molds with shell present only in the spire area. The long anterior canal is missing in the figured specimen (Fig. 9a).

A discussion of the taxonomic reasons for the use of the family Tudicidae in place of the normally used family Vasiidae is given in Zinsmeister (1983b).

Family Harpidae Bronn, 1849

Genus *Eocithara* P. Fischer, 1883

Type Species. By monotypy, *Harpa mutica* Lamarek, 1803.

Eocithara mutica californiensis (Vokes, 1937)

Figure 9b

Harpa (Eocithara) mutica n. sp. Clark and Vokes, 1936:pl. 2, fig. 5.

Harpa (Eocithara) mutica californiensis Vokes, 1937:11, pl. 2, figs. 2, 4, 6, 8.

Eocithara mutica californiensis (Vokes). Rehder, 1973:225, pl. 193.

Primary Type Material. UCMP holotype 30438, UCMP paratypes 30439–30449, Lajas Formation, UCMP locality 3296.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 373, 374.

Remarks. Four specimens were found in the Lajas Formation. Preservation is generally excellent with the thin colabral ridges present.

Family Volutidae Rafinesque, 1815

Subfamily Volutinae Rafinesque, 1815

Genus *Cryptochorda* Mörch, 1858

Type Species. By monotypy, *Buccinum stromboides* Herrmannsen.

Subgenus *Cryptochorda* s.s.

Cryptochorda (Cryptochorda) californica
(Cooper, 1894)

Figure 9c

Ancilla (Oliverato) californica Cooper, 1894:43, pl. 1, figs. 6–11. Dickerson, 1913:264; 1914:115, pl. 12, figs. 4a–b.

Oliverato californica Cooper. Dickerson, 1913:286–287, pl. 13, figs. 4a–b.

Caricella stormsiana Dickerson, 1913:287, pl. 13, figs. 3a–b.

Cryptochorda californica (Cooper). Clark, 1929:pl. 4, figs. 6, 16; pl. 9, figs. 5–6. Clark and Vokes, 1936:874, pl. 1, fig. 5. Turner, 1938:72, pl. 18, figs. 11, 15. Vokes, 1939:139–140. Weaver, 1943:499, pl. 95, figs. 19, 23.

Primary Type Material. CAS syntypes 8a–d (four specimens), Capay Formation, Marysville Buttes, Sutter County, California.

Molluscan Stage Range. “Capay” through “Domengine.”

Geographic Distribution. Simi Valley, California through southwestern Oregon.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 703.

Remarks. Only two specimens were found in the Lajas Formation.

According to Clark (1921:table 1; 1929), *C. (C.) californica* [= *Ancilla (Oliverato) californica*] occurs in “Meganos”-age strata. Such a report, however, cannot be substantiated at this time because of his lack of locality information and because his rock unit names are not clearly defined.

Genus *Lyria* Gray, 1847

Type Species. By original designation, *Voluta nucleus* Lamarck, 1811.

Lyria andersoni Waring, 1917

Figure 9d

Cancellaria irelaniana Cooper, 1894:42, pl. 1, fig. 5. Arnold, 1910:52, pl. 4, fig. 22. [Misidentification.]

Lyria andersoni Waring, 1917:97, pl. 15, fig. 12.

Lyria andersoni Waring. Clark, 1929:pl. 9, figs. 7–8. Clark and Vokes, 1936:876, pl. 1, fig. 17. Turner, 1938:73, pl. 18, fig. 5. Vokes, 1939:136, pl. 18, figs. 22, 24. Hanna and Hertlein, 1943:170, fig. 62-21.

Primary Type Material. SU holotype 195, SU paratype 196, Lajas Formation, SU locality 2696.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 439, 455, 466, 484, 498, 499, 507.

Remarks. This taxon helps to characterize the lower and middle parts of the shallow-marine (transgressive) facies. It is most common in the middle part. Preservation is generally good to excellent.

Subfamily Fulgorariinae

Pilsbry and Olsson, 1954

Genus *Lyrischapa* Aldrich, 1911

Type Species. By monotypy, *Lyrischapa harrisi* Aldrich, 1911.

Lyrischapa lajollaensis (Hanna, 1927)

Figure 9e

Pejonia lajollaensis Hanna, 1927:320, pl. 52, figs. 1–2.

Volutospira (*Pejonia*) *lajollaensis* (Hanna). Clark, 1929, pl. 9, figs. 11–12.

Volutocristata lajollaensis (Hanna). Gardner and Bowles, 1934:246, fig. 13. Givens, 1974:88.

Lyrischapa lajollaensis (Hanna). Givens, 1979:124–126, pl. 3, figs. 1–2; pl. 4, figs. 1–3. Givens and Kennedy, 1979: table 1.

Primary Type Material. Holotype lost, UCMP neotype 14634, Ardath Shale, UCMP locality 5062.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. San Diego through Pine Mountain area, southern California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 373, 374, 444, 445, 510, 543, 704.

Remarks. This taxon is most common in the “Stewart bed” at locality 374, where some rather large specimens (47 mm width) occur.

Hypotype specimens figured by Givens (1979) are from the Llajas Formation.

Family Cancellariidae
Forbes and Hanley, 1853

Genus *Bonellitia* Jousseume, 1887

Type Species. By original designation, *Cancellaria bonellii* Bellardi, 1872?

Subgenus *Admetula* Cossmann, 1889

Type Species. By original designation, *Cancellaria evulsa* Solander, 1776.

Bonellitia (*Admetula*) *paucivaricata*
(Gabb, 1864)

Figure 9f

Tritonium paucivaricatum Gabb, 1864:95, pl. 28, figs. 209, 209a.

Cancellaria stantoni Dickerson, 1913:282, pl. 12, figs. 2a–b.

Admete (*Bonellitia*) *stantoni* (Dickerson). Weaver and Palmer, 1922:40–42, pl. 11, figs. 1, 5.

Cancellaria paucivaricata (Gabb). Anderson and Hanna, 1925:81, pl. 8, figs. 3–4.

Bonellitia (*Admetula*) *paucivaricata* (Gabb). Stewart, 1927: 413, pl. 29, fig. 5. Turner, 1938:71, pl. 15, figs. 12–13. Weaver, 1943:508, pl. 96, figs. 10, 12, 13; pl. 103, figs. 9, 10, 17. Givens, 1974:89. Squires, 1977:table 1.

Primary Type Material. ANSP lectotype 4194, Tejon Formation, Tejon Pass area, California.

Molluscan Stage Range. “Meganos”?, “Capay” through “Tejon.”

Geographic Distribution. Simi Valley, California through southwestern Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371.

Remarks. Only seven specimens were found in the Llajas Formation. According to Clark (1921:table 1; 1926:115), *B. (A.) paucivaricata* [= *Cancellaria stantoni* and *Admete stantoni*] occurs in “Meganos”-age strata. Such a report, however, cannot be substantiated at this time because of his lack of locality information and because his rock unit names are not clearly defined. Clark and Woodford (1927), however, reported a questionable occurrence of *B. (A.) paucivaricata* [= *Admete* (*Bonellitia*) cf. *stantoni*] from localities of late Paleocene/early Eocene age strata.

Superfamily Conacea

Family Turridae Swainson, 1840

Subfamily Turriculinae Powell, 1942

Genus *Pleurofusua* de Gregorio, 1890

Type Species. By original designation, *Pleurotoma* (*Pleurofusua*) *longirostropis* de Gregorio, 1890.

Pleurofusua fresnoensis (Arnold, 1910)

Figure 9g

Pleurotoma fresnoensis Arnold, 1910:53, pl. 4, fig. 23.

Surcula clarki Dickerson, 1913:278, pl. 11, fig. 3.

Pleurofusua fresnoensis (Arnold). Vokes, 1939:117–118, pl. 17, figs. 15–16. Givens, 1974:90, pl. 11, fig. 9. Givens and Kennedy, 1979:95, tables 1, 3.

Primary Type Material. USNM holotype 165631, Domengine Formation, USGS locality 4619.

Molluscan Stage Range. “Capay” through “Transition.”

Geographic Distribution. San Diego through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 538, 539.

Remarks. Specimens are most common at locality 371.

According to Clark (1921:table 1; 1926:116), *P. fresnoensis* [= *Turris* (*Surcula*) *clarki* and *Surcula clarki*] occurs in “Meganos”-age strata. Such a report, however, cannot be substantiated at this time because of his lack of locality information and because his rock unit names are not clearly defined.

Smith (1975:table 1) reported *Pleurofusua* sp. aff. *P. fresnoensis* from “Martinez”-age strata of central California.

Genus *Fusiturricula* Woodring, 1928

Type Species. By original designation, *Turris* (*Surcula*) *fusinella*.

Subgenus *Crenaturricula* Vokes, 1939

Type Species. By original designation, *Surcula crenatospira* Cooper, 1894.

Fusiturricula (*Crenaturricula*) *crenatospira*
(Cooper, 1894)

Figure 9h

Surcula crenatospira Cooper, 1894:39, pl. 1, figs. 2–4. Dickerson, 1913:278, pl. 11, fig. 4.

Fusiturricula (Crenaturricula) crenatospira (Cooper). Vokes, 1939:114–115, pl. 17, figs. 4–5.

Primary Type Material. CAS syntypes 9a–b (two specimens), Capay Formation, UCMP locality 1853.

Molluscan Stage Range. “Capay” through “Domengine.”

Geographic Distribution. Simi Valley through Marysville Buttes, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only two specimens were found, and these are from the “Stewart bed.” According to Vokes (1939:15) this taxon is confined to and is diagnostic of the “Capay Stage.” The presence of it in the “Stewart bed” extends its provincial range into the “Domengine Stage.”

According to Clark (1921:table 1; 1929), *F. (C.) crenatospira* [= *Turris (Surcula) crenatospira* and *Turricula crenatospira*] occurs in “Meganos”-age strata. Such a report, however, cannot be substantiated at this time because of his lack of locality information and because his rock unit names are not clearly defined.

Fusiturricula (Crenaturricula) crenatospira domenginica Vokes, 1939

Figure 9i

Fusiturricula (Crenaturricula) crenatospira domenginica Vokes, 1939:115–116, pl. 17, figs. 6–7.

Primary Type Material. UCMP holotype 15768, Llajas Formation, UCMP locality 7002; UCMP paratype 15769, Llajas Formation, UCMP locality 3304.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 374, 444, 445, 498, 548.

Remarks. At locality 374, this taxon occurs along with *F. (C.) crenatospira*, which is characterized by the presence of collabral sculpturing below the nodes on the spire and body whorls. On *F. (C.) crenatospira domenginica*, the collabral sculpturing is obsolete. Contrary to Vokes’ (1939:115–116) comments, the two taxa have approximately the same number of nodes on the body whorl.

Genus *Surculites* Conrad, 1865

Type Species. By monotypy, *Surcula (Surculites) annosus* Conrad, 1865.

Surculites mathewsonii (Gabb, 1864)

Figure 9j

Fusus mathewsonii Gabb, 1864:83, pl. 18, fig. 33. Dickerson, 1914:pl. 16, fig. 2.

Bela clathra Gabb, 1869:152, pl. 26, fig. 31.

?*Pleurotoma decipiens* Cooper, 1894:40, pl. 2, fig. 32.

Potamides? davisiana Cooper, 1894:44, pl. 1, fig. 13.

Surcula davisiana (Cooper). Dickerson, 1913:279, pl. 12, figs. 6a–b.

Surcula (?) sp. Waring, 1917:pl. 15, fig. 16.

Surcula decipiens (Cooper). Hanna, 1927:324, pl. 54, figs. 6, 8.

Surculites mathewsonii (Gabb). Stewart, 1927:420–421, pl. 26, figs. 12–14. Clark, 1929:pl. 9, figs. 3–4. Turner, 1938:69–70, pl. 17, figs. 6, 10. Vokes, 1939:123, pl. 17, figs. 8, 19. Weaver, 1943:526, pl. 97, figs. 24, 29; pl. 98, figs. 1, 5; 1953:29. Givens, 1974:90, pl. 11, figs. 5, 7. Zinsmeister, 1974:164, pl. 17, fig. 6; 1983a:table 1. Squires, 1977:table 1. Givens and Kennedy, 1979:87, tables 1, 3.

“*Surculites*” *mathewsonii* (Gabb). Smith, 1975:pl. 2, fig. 15.

Primary Type Material. ANSP lectotype 4180, Tejon Formation s.l., near Martinez, California.

Molluscan Stage Range. Lower “Martinez” through “Transition.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 374, 444, 445, 447, 479, 498.

Remarks. Specimens are fairly common at locality 371 but are more common and larger at locality 374 of the “Stewart bed.” At locality 374, the specimens are internal molds. Specimens at locality 371 are strongly angulated, which is in keeping with one of the main characteristics of this species as discussed by Vokes (1939:123).

Genus *Domenginella* Vokes, 1939

Type Species. By original designation, *Turris claytonensis* Gabb, 1864.

Domenginella claytonensis (Gabb, 1864)

Figure 9k

Turris claytonensis Gabb, 1864:92, pl. 18, fig. 46.

Surcula gesteri Dickerson, 1916:499, pl. 42, fig. 4.

Scobinella claytonensis (Gabb). Stewart, 1927:417–418, pl. 27, figs. 11–12.

Domenginella claytonensis (Gabb). Vokes, 1939:122–123, pl. 17, figs. 18, 20.

Primary Type Material. ANSP lectotype 4190, Tejon Formation s.l., near Martinez, California.

Molluscan Stage Range. Uppermost “Capay” through “Domengine.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 469a. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 455, 466, 484, 486, 498, 517, 538, 539, 548.

Remarks. This taxon is most common at locality 371, where most of the specimens are well-preserved juveniles.

The presence of *D. claytonensis* in the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine (transgressive) facies of the Llajas Formation extends the molluscan stage range of this taxon into the uppermost

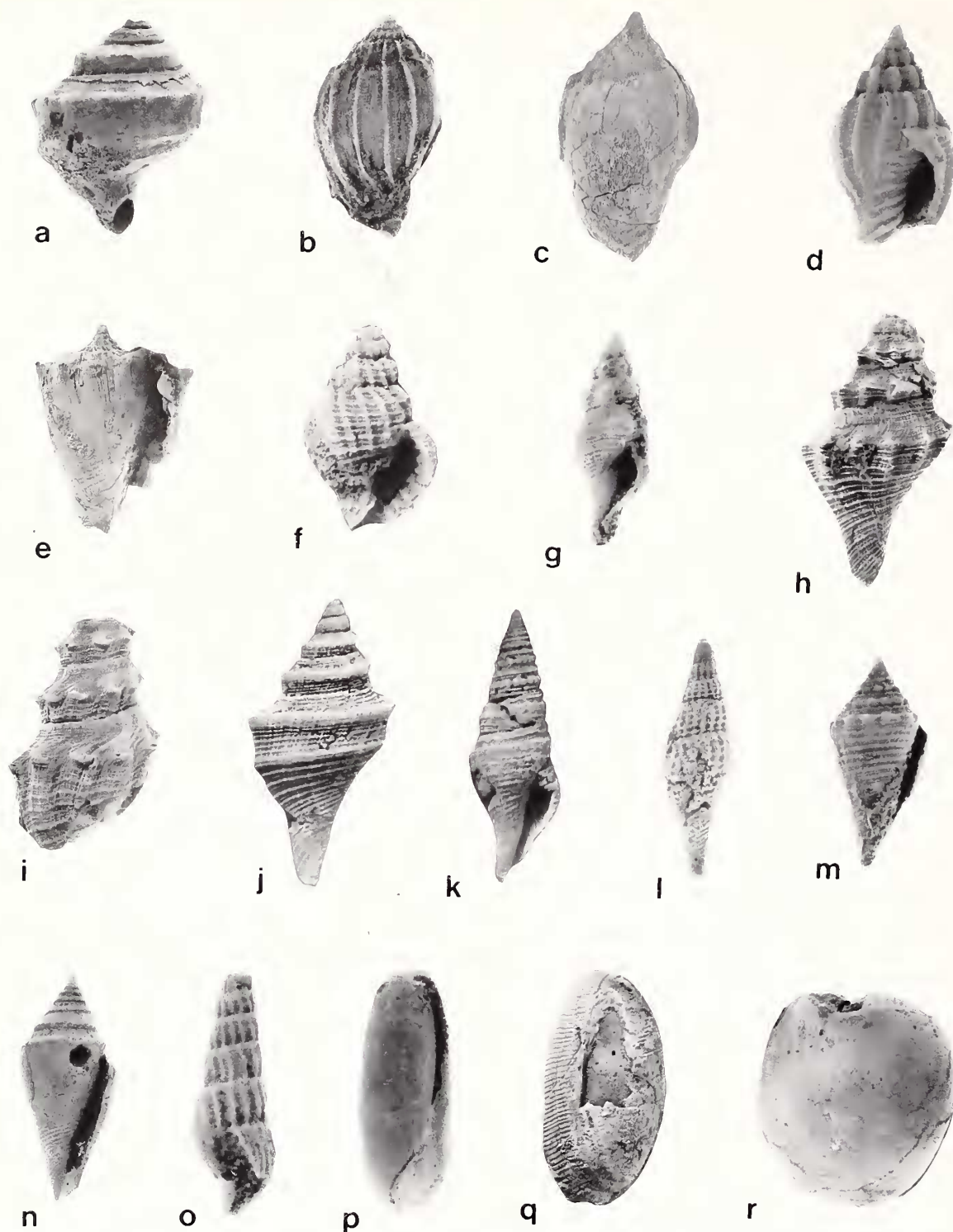


Figure 9. Llajas Formation gastropods (continued). Unless otherwise indicated, views are apertural. **a.** *Pseudoperissolax blakei praeblakei* Vokes, 1939, internal mold, side view, LACMIP hypotype 6547, CSUN loc. 374, $\times 1.5$. **b.** *Eocithara mutica californiensis* (Vokes, 1937), abapertural view, LACMIP hypotype 6548, CSUN loc. 373, $\times 1.5$. **c.** *Cryptochorda* (*Cryptochorda*) *californica* (Cooper, 1894), abapertural view, LACMIP hypotype 6549, CSUN loc. 703, $\times 1.25$. **d.** *Lyria andersoni* Waring, 1917, LACMIP hypotype 6550, CSUN loc. 498, $\times 2$. **e.** *Lyrischapa lajollaensis* (Hanna, 1927), LACMIP hypotype 6551, CSUN loc. 373, $\times 1$. **f.** *Bonellita* (*Admetula*) *paucivariata* (Gabb, 1864), LACMIP hypotype 6552, CSUN loc. 374, $\times 4.5$. **g.** *Pleurofusua fresnoensis* (Arnold, 1910), LACMIP hypotype 6553, CSUN loc. 371, $\times 3$. **h.** *Fusiturricula* (*Crenaturricula*) *crenatospira* (Cooper, 1894), abapertural view, UCLA hypotype 59278, CSUN loc. 374, $\times 1.5$. **i.** *Fusiturricula* (*Crenaturricula*) *crenatospira domenginica* Vokes, 1939, abapertural view, LACMIP hypotype 6554, CSUN loc. 371, $\times 1$. **j.** *Surculites ma-*

“Capay.” Previously, the lower range limit had been reported as the “Domengine Stage” (Vokes, 1939).

Genus *Exilia* Conrad, 1860

Type Species. By monotypy, *Exilia pergracilis* Conrad, 1860.

Exilia llajasensis Bentson, 1940

Figure 9l

Exilia llajasensis Bentson, 1940:212, pl. 1, fig. 28; pl. 2, fig. 16.

Primary Type Material. UCMP holotype 12144, Llajas Formation, UCMP locality A-3042; UCMP paratype 12140, Llajas Formation, UCMP locality 3296.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 486, 539.

Remarks. Only two specimens were found in the Llajas Formation. In the primary type specimens, the anterior canal is missing. As can be seen in Figure 9l, the long anterior canal is covered by 10 spiral ribs.

Family Conidae Rafinesque, 1815

Genus *Conus* Linné, 1758

Type Species. By subsequent designation (Children, 1823), *Conus marmoreus* Linné, 1758.

Conus caleocius Vokes, 1939

Figure 9m

Conus caleocius Vokes, 1939:127–129, pl. 18, figs. 1, 7.

Primary Type Material. UCMP holotype 15785, Llajas Formation, UCMP locality 3310.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 498.

Remarks. Four specimens were found. Three of these are from locality 371.

Conus hornii umpquaensis Turner, 1938

Figure 9n

Conus hornii umpquaensis Turner, 1938:69, pl. 15, figs. 1–2. Vokes, 1939:127, pl. 18, figs. 2–3. Stewart, 1946:pl. 11,

fig. 6. Weaver, 1943:510–511, pl. 96, fig. 18. Givens and Kennedy, 1979:87, tables 1, 3.

Primary Type Material. UCMP holotype 33656, “upper Umpqua” Formation, UO locality 144.

Molluscan Stage Range. “Domengine” through “Transition.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 374, 449, 455, 484, 486, 491, 498, 538, 539.

Remarks. This taxon characterizes the lower half of the shallow-marine (transgressive) facies. It is especially abundant at locality 371, where it forms a growth series.

Family Terebridae H. and A. Adams, 1854

Genus *Terebra* Bruguière, 1789

Type Species. By subsequent designation (Lamarck, 1799), *Buccinum subulata* Linné, 1758.

Terebra californica Gabb, 1869

Figure 9o

Terebra californica Gabb, 1869:162, pl. 27, fig. 41.

Terebra californica Gabb. Anderson and Hanna, 1925:82, pl. 8, fig. 18. Stewart, 1927:424, pl. 26, fig. 5. Vokes, 1939:113, pl. 16, fig. 38. Givens, 1974:92.

Primary Type Material. ANSP holotype 4209, Tejon Formation s.l., Martinez, California.

Molluscan Stage Range. “Domengine” through “Tejon.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 467.

Remarks. Only two specimens were found. They are very small, with heights of 3 mm.

Subclass Euthyneura

Order Cephalaspidea

Superfamily Cylichnacea A. Adams, 1850

Family Cylichnidae A. Adams, 1850

Genus *Cylichnina* Monterosato, 1884

Type Species. By original designation, *Bulla umbilicata* Montagu, 1803.

thewsonii (Gabb, 1864), abapertural view, LACMIP hypotype 6555, CSUN loc. 371, $\times 2.5$. **k.** *Domenginella claytonensis* (Gabb, 1864), side view, LACMIP hypotype 6556, CSUN loc. 371, $\times 2.5$. **l.** *Exilia llajasensis* Bentson, 1940, LACMIP hypotype 6557, CSUN loc. 539, $\times 2.5$. **m.** *Conus caleocius* Vokes, 1939, LACMIP hypotype 6558, CSUN loc. 498, $\times 2$. **n.** *Conus hornii umpquaensis* Turner, 1938, LACMIP hypotype 6559, CSUN loc. 371, $\times 2.5$. **o.** *Terebra californica* Gabb, 1869, LACMIP hypotype 6560, CSUN loc. 467, $\times 8$. **p.** *Cylichnina tantilla* (Anderson and Hanna, 1925), LACMIP hypotype 6561, CSUN loc. 371, $\times 2.5$. **q.** *Scaphander* (*Mirascapha*) *costatus* (Gabb, 1864), abapertural view, LACMIP hypotype 6562, CSUN loc. 493, $\times 1.5$. **r.** *Megistostoma gabbianum* (Stoliczka, 1868), internal mold, abapertural view, LACMIP hypotype 6553, CSUN loc. 458, $\times 1.5$.

Cylichnina tantilla
(Anderson and Hanna, 1925)

Figure 9p

Cylichnella tantilla Anderson and Hanna, 1925:140, pl. 7, figs. 4, 8–9.

Cylichnina tantilla (Anderson and Hanna). Stewart, 1927: 439–441, pl. 27, figs. 2–4. Turner, 1938:67–68, pl. 20, figs. 9–10. Vokes, 1939:110, pl. 16, figs. 28, 33, 39. Weaver, 1943:548–549, pl. 100, figs. 10–12, 14–15. Stewart, 1946: pl. 11, fig. 11. Givens, 1974:93. Squires, 1977:table 1; 1983b, fig. 9a.

Primary Type Material. CAS holotype 958, CAS paratypes 959 and 960, Tejon Formation, CAS locality 711.

Molluscan Stage Range. “Domengine” through “Tejon.”

Geographic Distribution. Simi Valley, California through western Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 372, 373, 374, 455, 460, 466, 467, 469e, 469f, 484, 486, 491, 492, 498, 499, 507, 508, 517, 537, 538, 540, 543. Shallow-marine (regressive) facies: CSUN locality 475.

Remarks. This easily recognized taxon is especially abundant at localities 371, 373, and 455. At these localities it occurs as growth series.

Genus *Scaphander* Montfort, 1810

Type Species. By original designation, *Bulla lignaria* Linné, 1767.

Subgenus *Mirascapha* Stewart, 1927

Type Species. By original designation, *Cylichna costata* Gabb, 1864.

Scaphander (Mirascapha) costatus
(Gabb, 1864)

Figure 9q

Cylichna costata Gabb, 1864:143–144, pl. 21, fig. 107. Arnold, 1907:pl. 39, fig. 10. Zinsmeister, 1974:170–171, pl. 12, figs. 20–22.

Scaphander costata (Gabb). Hanna, 1927:329, pl. 57, figs. 2, 3, 5.

Scaphander (Mirascapha) costatus (Gabb). Stewart, 1927: 437–438, pl. 27, fig. 5. Turner, 1938:67, pl. 17, fig. 16. Vokes, 1939:109, pl. 16, figs. 29, 35. Givens, 1974:93–94.

Scaphander costatus (Gabb). Weaver, 1943:545, pl. 100, fig. 2; pl. 103, fig. 21. Weaver, 1953:29. Givens and Kennedy, 1979:88, table 3.

Primary Type Material. ANSP lectotype 4338, Tejon Formation s.l., near Martinez, California.

Molluscan Stage Range. “Martinez” through “Transition.”

Geographic Distribution. San Diego, California through western Washington.

Local Occurrence. Shallow-marine (transgressive) facies:

CSUN locality 493. Shallow-marine (regressive) facies: CSUN locality 475.

Remarks. Only a few specimens were found in the Llajas Formation.

Family Philinidae Gray, 1850

Genus *Megistostoma* Gabb, 1864

Type Species. By monotypy, *Megistostoma striata* Gabb, 1864.

Megistostoma gabbianum (Stoliczka, 1868)

Figure 9r

Megistostoma striata Gabb, 1864:144, pl. 21, figs. 108a–b. Not *Bullaea striata* Deshayes, 1824:37, pl. 5, figs. 1–3.

Bullaea gabbiana Stoliczka, 1868:434 [new name for *Megistostoma striata* Gabb, 1864, preoccupied].

Philine (Megistostoma) gabbi Cossmann, 1895:127 [new name for *Megistostoma striata* Gabb, 1864, preoccupied].

Megistostoma gabbianum (Stoliczka). Stewart, 1927:441–442, pl. 26, figs. 1–2. Vokes, 1939:112, pl. 17, figs. 1–3. Givens and Kennedy, 1979:88, table 3.

Megistostoma caminoensis Hanna, 1927:330, pl. 57, figs. 9–10. Turner, 1938:68, pl. 20, fig. 15. Weaver, 1943:541, pl. 99, fig. 24.

Primary Type Material. ANSP holotype 4216 of *Megistostoma striata* Gabb, *Bullaea gabbiana* Stoliczka, and *Philine (Megistostoma) gabbi* Cossmann, Tejon Formation s.l., near Martinez, California.

Molluscan Stage Range. “Domengine” through “Transition.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 458. Shallow-marine (regressive) facies: CSUN locality 462.

Remarks. Only a few specimens were found in the Llajas Formation, and they occur as internal molds.

Class Bivalvia

Subclass Palaeotaxodonta

Order Nuculoida

Superfamily Nuculacea

Family Nuculidae Gray, 1824

Genus *Acila* H. & A. Adams, 1858

Type Species. By subsequent designation (Stoliczka, 1871), *Nucula divaricata* Hinds, 1843.

Subgenus *Truncacila* Schenck, in
Grant and Gale, 1931

Type Species. By original designation *Nucula castrensis* Hinds, 1843.

Acila (Truncacila) decisa (Conrad, 1855)

Figure 10a

Nucula decisa Conrad, 1855:11–12; 1857:pl. 3, fig. 19.
Acila gabbiana Dickerson, 1916:481, pl. 36, fig. 1. Anderson and Hanna, 1925:176, pl. 9, fig. 12.
Nucula (Acila) stillwaterensis Weaver and Palmer, 1922:6, pl. 8, fig. 8.
Acila lajollaensis Hanna, 1927:270, pl. 25, figs. 1, 3, 5, 7–8, 12, 15.
Acila (Truncacila) decisa (Conrad). Schenck, 1936:53–56, pl. 3, figs. 1–9, 11–15; pl. 4, figs. 1–2; text figure 7 (22, 23, 25). Turner, 1938:41–42, pl. 5, figs. 2–3. Vokes, 1939:41, pl. 1, figs. 7–8. Weaver, 1943:22–23, pl. 6, figs. 1, 4, 8; pl. 7, figs. 8–9. Givens, 1974:38, pl. 1, fig. 1. Zinsmeister, 1974:67–68, pl. 6, fig. 3. Squires, 1977:table 1. Moore, 1983:A10, pl. 1, fig. 14. Zinsmeister, 1983a:table 1.

Primary Type Material. UCMP neotype 31132, Ardath Shale, UCMP locality 5062.

Molluscan Stage Range. “Martinez” through upper Eocene (*Turritella schencki delaguerrae* Zone of Kleinpell and Weaver, 1963).

Geographic Distribution. San Diego, California through Kamchatka, Alaska.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 467.

Remarks. Specimens are abundant at locality 467. Preservation is excellent. The specimens are disarticulated, but the valves constitute a growth series.

Superfamily Nuculanacea

Family Nuculanidae H. and A. Adams, 1858

Genus *Nuculana* Link, 1807

Type Species. By original designation, *Arca rostrata* Chemnitz, 1784 [= *Arca pernula* Müller, 1776].

Subgenus *Saccella* Woodring, 1925

Type Species. By original designation, *Arca fragilis* Chemnitz, 1784.

Nuculana (Saccella) gabbii (Gabb, 1864)

Figure 10b

Not *Leda protexta*? Gabb, 1860:303, pl. 48, fig. 23.
Leda protexta? Gabb, 1864:199 (in part), pl. 26, fig. 185.
Nuculana gabbii Conrad, 1866:3 [nomen nudum].
Leda gabbii Conrad. Gabb, 1869:197 [new name for *Leda protexta*? Gabb, 1864, misidentified]. Stanton, 1896:1041, pl. 64, fig. 8. Waring, 1917:76, pl. 13, fig. 6. Dickerson, 1915:pl. 1, fig. 1; 1916, pl. 36, fig. 3. Clark and Woodford, 1927:85–86, pl. 14, fig. 2. Clark, 1929:pl. 3, fig. 12.
Leda vaderensis Dickerson, 1915:52, pl. 1, fig. 3.
Leda vogdesi Anderson and Hanna, 1925:177–179, pl. 2, figs. 8–9.
Saccella gabbii (Gabb). Stewart, 1930:55–58, pl. 7, fig. 3 [not pl. 10, fig. 4. = *N. (S.) alaeformis* fide Zinsmeister, 1974]. Weaver, 1953:28.

Nuculana (Saccella) gabbii (Gabb). Vokes, 1939:41–42. Kleinpell and Weaver, 1963:195, pl. 28, fig. 1. Givens, 1974:39, pl. 1, fig. 3. Moore, 1983:A16, pl. 2, figs. 7–8.
Nuculana (Calorhadia) gabbii (Gabb). Zinsmeister, 1974:69–70, pl. 6, fig. 7; 1983a, pl. 1, fig. 3.

Primary Type Material. ANSP lectotype 4476 of *Leda gabbii* Gabb, 1869, Tejon Formation s.l., Martinez, California.

Molluscan Stage Range. “Martinez” through upper Eocene (*Turritella schencki delaguerrae* Zone of Kleinpell and Weaver, 1963).

Geographic Distribution. Simi Valley, California through Kamchatka, Alaska.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 467.

Remarks. Only five disarticulated valves were found in the Lajas Formation. There is considerable variation in the amount of elongation of the rostrum in these specimens, with the illustrated specimen (Fig. 10b) showing the most.

According to Zinsmeister (1974), Stewart (1930) somehow confused *N. (S.) gabbii* with *N. (S.) alaeformis* and designated *N. (S.) alaeformis* (pl. 10, fig. 4) as the lectotype (ANSP 4476) of *N. (S.) gabbii*.

Subclass Pteriomorpha

Order Arcoida

Superfamily Limnopsacea

Family Glycymerididae Newton, 1922

Subfamily Glycymeridinae Newton, 1922

Genus *Glycymeris* da Costa, 1778

Type Species. By tautonymy, *Arca orbicularis* da Costa, 1778 [= *Arca glycymeris* Linné, 1758].

Subgenus *Glycymeris* s.s.

Glycymeris (Glycymeris) rosecanyonensis

Hanna, 1927

Figure 10c

Glycymeris rosecanyonensis Hanna, 1927:273–274, pl. 27, figs. 4–5, 9, 11. Clark, 1929:pl. 6, fig. 8. Givens and Kennedy, 1979:tables 1, 3.
Glycymeris (Glycymeris) rosecanyonensis Hanna. Givens, 1974:42. Moore, 1983:A49–A50, pl. 10, figs. 12–13.
Glycymeris (Glycymeris) rosecanyonensis Hanna. Squires, 1977:table 1.

Primary Type Material. UCMP holotype 30989, Ardath Shale, UCMP locality 3990.

Molluscan Stage Range. “Domengine” through “Transition.”

Geographic Distribution. San Diego through lower Piru Creek, southern California.

Local Occurrence. Shallow-marine (transgressive) facies:

CSUN localities 373, 467, 471d, 520. Shallow-marine (regressive) facies: CSUN localities 476, 489, 512a, 512b.

Remarks. Only a few specimens of this small-sized bivalve were found in the Lajas Formation.

Subgenus *Glycymerita*
Finlay and Marwick, 1937

Type Species. By original designation, *Glycymeris concava* Marshall, 1917.

Glycymeris (Glycymerita) sagittata
(Gabb, 1864)

Figure 10d

Axinaea (Limopsis?) sagittata Gabb, 1864:197–198, pl. 31, figs. 267, 267a.

Glycymeris hannibali Dickerson, 1916:483, pl. 36, figs. 8a–b.

Glycymeris sagittatus (Gabb). Dickerson, 1916:pl. 36, figs. 5a–b.

Glycymeris sagittata (Gabb). Anderson and Hanna, 1925:181–182, pl. 1, fig. 6. Stewart, 1930:71–73, pl. 12, fig. 10; 1946:pl. 12, fig. 3. Vokes, 1939:45–46, pl. 1, figs. 18–20. Weaver, 1943:54–55, pl. 9, figs. 17–18; pl. 11, fig. 15. Kleinpell and Weaver, 1963:196–197, pl. 28, fig. 10; pl. 29, figs. 1–2.

Glycymeris sagittatus (Gabb). Turner, 1938:43–44, pl. 6, figs. 1–3.

Glycymeris (Glycymerita) sagittata (Gabb). Givens, 1974:42–43. Squires, 1977:table 1. Moore, 1983:A54–A55, pl. 12, fig. 17.

Primary Type Material. ANSP lectotype 4422, Tejon Formation, near Fort Tejon (N ½ of section 29, T 10 N, R 19 W, Kern County, California).

Molluscan Stage Range. “Capay” through “Tejon,” Oligocene?.

Geographic Distribution. Simi Valley, California through southwestern Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 374, 444, 500, 704.

Remarks. Specimens are uncommon in the Lajas Formation, and leaching has obscured some of the exterior sculpture.

Order Mytiloida

Superfamily Mytilacea

Family Mytilidae Rafinesque, 1815

Genus *Brachidontes* Swainson, 1840

Type Species. By monotypy, *Modiola sulcata* Lamarck, 1819 (not 1805) [= *Mytilus citrinus* Röding, 1798, = *Arca modiolus* Linné, 1767].

Subgenus *Brachidontes* s.s.

Brachidontes (Brachidontes) cowlitzensis
(Weaver and Palmer, 1922)

Figure 10e

Modiola ornata Gabb, 1864:184–185, pl. 24, fig. 166.

Not *Mytilus ornatus* Orbigny, 1843:283, pl. 342, figs. 10–12.

Modiolus ornatus Gabb. Arnold, 1907:pl. 38, fig. 4.

Brachyontes ornatus (Gabb). Anderson and Hanna, 1925:188, pl. 3, fig. 4.

Modiolus (Brachyontes) ornatus Gabb. Clark and Woodford, 1927:89, pl. 14, fig. 10. Clark, 1929:pl. 3, fig. 6.

Modiolus (Brachyontes) cowlitzensis Weaver and Palmer, 1922:16–17, pl. 9, fig. 19 [new name for *Modiola ornata* Gabb, 1864, preoccupied].

Brachidontes cowlitzensis? (Weaver and Palmer). Stewart, 1930:100–103, pl. 8, fig. 12.

Brachidontes cowlitzensis (Weaver and Palmer). Turner, 1938:45–46, pl. 6, figs. 7–8. Kleinpell and Weaver, 1963:197, pl. 29, fig. 3. Wolfe, 1977:3. Givens and Kennedy, 1979:table 2.

Volsella (Brachidontes) cowlitzensis (Weaver and Palmer). Weaver, 1943:113–114, pl. 26, fig. 4.

Brachidontes (Brachidontes) cowlitzensis (Weaver and Palmer). Givens, 1974:43. Squires, 1977, table 1. Moore, 1983:A66–A67, pl. 17, fig. 1.

Primary Type Material. ANSP lectotype 4450 of *Modiola ornata* Gabb, Domengine? Formation, Martinez, California. CAS holotype 7406 of *Modiolus (Brachyontes) ornatus* Weaver and Palmer, Cowlitz Formation, UW locality 329.

Molluscan Stage Range. “Meganos” through lower Oligocene (*Turritella variata lorenzana* Zone of Kleinpell and Weaver, 1963).

Geographic Distribution. San Diego, California through Gulf of Alaska.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 374, 455, 466, 471d, 492, 514, 528. Shallow-marine (regressive) facies: CSUN locality 512d.

Remarks. Specimens are most common at locality 371, where they are fragile, well-preserved single valves.

Superfamily Pinnacea

Family Pinnidae Leach, 1819

Genus *Pinna* Linné, 1758

Type Species. By subsequent designation (Children, 1823), *Pinna rudis* Linné, 1758.

***Pinna lewisi* Waring, 1917**

Figure 10f

Pinna lewisi Waring, 1914:785; 1917:94, pl. 15, fig. 24.

Pinna (Pinna) lewisi Waring. Moore, 1983:A79, pl. 21, fig. 10.

Primary Type Material. CAS/SU holotype 5194, Lajas Formation, SU locality 2696.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley through south end of San Joaquin Valley, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 548. Shallow-marine (regressive) facies: CSUN locality 475.

Remarks. Only six specimens were found, and five are from locality 475. Preservation is mostly as internal molds, and four specimens are articulated. The following supplementary comments are based on an examination of the holotype. It is mostly an internal mold with 95 percent of the shell missing. There are 16 to 18, very closely spaced radial ribs and about nine comarginal ribs on each valve. The holotype and the Lajas specimens have a median sulcus.

Pinna llajasensis Squires, 1983a

Figure 10g

Pinna n. sp. Vokes, 1939:50, pl. 2, fig. 14. Moore, 1983:A79, pl. 22, fig. 1.

Pinna llajasensis Squires, 1983a:359–360, fig. 21.

Primary Type Material. UCLA holotype 59196, Lajas Formation, CSUN locality 458.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 458.

Remarks. Only two specimens were found and these are from the "Stewart bed." Both are articulated, incomplete specimens (Squires, 1983). The holotype is the figured specimen (Fig. 10g).

P. llajasensis differs from *P. lewisi* in having fewer radial ribs (only 12) which are more widely spaced. *P. llajasensis* also has no comarginal sculpture.

In the original description by Vokes (1939) of his *Pinna* n. sp., he mentioned that his specimen (UCMP 32595, Domengine Formation, UCMP locality 2287) had 23 ribs. The following supplementary comments are based on an examination of the holotype. There are 12 ribs per single valve and about 23 for the entire surface including both valves.

Order Pterioida

Suborder Pteriina

Superfamily Pteriacea

Family Malleidae Lamarck, 1819

Genus *Nayadina* Munier-Chalmas, 1864

Type Species. By monotypy, *Nayadina herberti* Munier-Chalmas, 1864.

Subgenus *Exputens* Clark, 1934

Type Species. By subsequent designation (Vokes, 1939), *Exputens llajasensis* Clark, 1934.

Nayadina (Exputens) llajasensis (Clark, 1934)

Figures 10h–i

Exputens llajasensis Clark, 1934:270–271, pl. 37, figs. 11–18. Vokes, 1939:51.

Nayadina (Exputens) llajasensis (Clark). Givens, 1974:44, pl. 1, fig. 9. Moore, 1983:A86–A87, pl. 26, figs. 10, 13.

Primary Type Material. UCMP holotype 32391, UCMP paratypes 32390, 32393, Lajas Formation, UCMP locality 7004 = CSUN locality 374.

Molluscan Stage Range. "Capay" through "Domengine."

Geographic Distribution. Simi Valley through Pine Mountain area, southern California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 445, 447, 471b, 473, 479, 480.

Remarks. Specimens occur mainly in the "Stewart bed" at and in the vicinity of locality 374. In addition, a few specimens were found in glauconitic siltstone at locality 473, about 14 m above the "Stewart bed" at the type section. The bed that locality 473 occurs in probably represents a shallow-marine (transgressive) facies bed that interfingers with the outer shelf and slope facies. At localities 374 and 473, a few of the specimens are articulated.

Superficially, this genus may resemble *Hiatella*, but *Hiatella* is a heterodont with two weak teeth whereas *Nayadina* lacks hinge teeth. A view of the hinge of *N. (E.) llajasensis* is given in Figure 10i.

Superfamily Pectinacea

Family Spondylidae Gray, 1826

Genus *Spondylus* Linné, 1758

Type Species. By subsequent designation (Schmidt, 1818), *Spondylus gaederopus* Linné, 1758.

Spondylus carlosensis Anderson, 1905

Figure 10j

Spondylus carlosensis Anderson, 1905:194, pl. 13, fig. 1. Arnold, 1910:pl. 2, figs. 6–7. Dickerson, 1915:pl. 1, fig. 7. Anderson and Hanna, 1925:189–190, text figure 10. Vokes, 1939:57, pl. 3, figs. 10, 13. Kleinpell and Weaver, 1963:199, pl. 31, fig. 6.

Primary Type Material. CAS holotype 56, Domengine Formation, west and north of Coalinga, NW ¼ of section 35, T 20 S, R 14 E, Fresno County, California.

Molluscan Stage Range. "Domengine."

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 438, 444, 525.

Remarks. Specimens are relatively uncommon in the Lajas Formation, and they consist of fragments of single valves. The most complete and best preserved specimens are from locality 374.

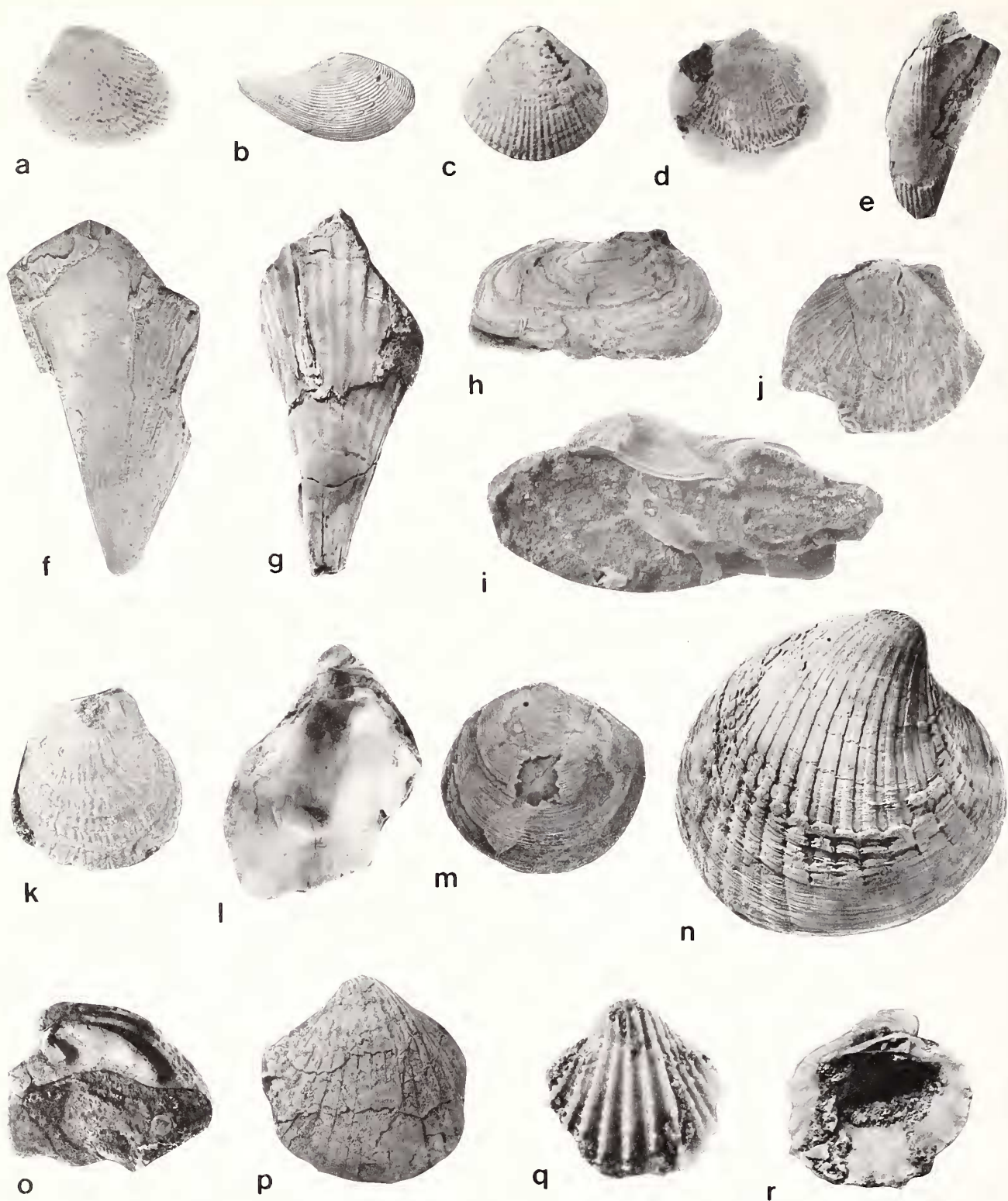


Figure 10. Lajas Formation bivalves. **a.** *Acila (Truncacila) decisa* (Conrad, 1855), right valve, LACMIP hypotype 6554, CSUN loc. 467, $\times 3.5$. **b.** *Nuculana (Saccella) gabbi* (Gabb, 1864), right valve, UCLA hypotype 59279, CSUN loc. 467, $\times 3$. **c.** *Glycymeris (Glycymeris) rosecanyonensis* Hanna, 1927, right? valve, LACMIP hypotype 6565, CSUN loc. 489, $\times 4.5$. **d.** *Glycymeris (Glycymerita) sagittata* (Gabb, 1864), right? valve, LACMIP hypotype 6566, CSUN loc. 371, $\times 2$. **e.** *Brachidontes (Brachidontes) cowlitzensis* (Weaver and Palmer, 1922), right valve, LACMIP hypotype 6567, CSUN loc. 371, $\times 1.5$. **f.** *Pinna lewisi* (Waring, 1917), internal mold of right? valve, LACMIP hypotype

Superfamily Anomiacea

Family Anomiidae Rafinesque, 1815

Genus *Anomia* Linné, 1758

Type Species. By subsequent designation (Schmidt, 1818), *Anomia ephippium* Linné, 1758.

Anomia mcgoniglenensis Hanna, 1927

Figure 10k

Anomia mcgoniglenensis Hanna, 1927:278, pl. 31, figs. 1, 2, 5, 7. Turner, 1938:46, pl. 6, figs. 4–6. Weaver, 1943:100, pl. 22, figs. 4–5. Givens and Kennedy, 1976:974, pl. 4, figs. 13–16. Givens and Kennedy, 1979:table 2.

Primary Type Material. UCMP syntypes 31009–31010, Delmar Formation, UCMP locality 3981.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 438.

Remarks. Only three specimens were found in the Lajas Formation. They occur as single valves unattached to any hard substrate.

Suborder Ostreina

Superfamily Ostreacea

Family Ostreidae Rafinesque, 1815

Subfamily Ostreinae Rafinesque, 1815

Genus *Ostrea* Linné, 1758

Type Species. By subsequent designation (ICZN opin. 94 and 356), *Ostrea edulis* Linné, 1758.

Ostrea idriaensis Gabb, 1869

Figure 10l

Ostrea idriaensis Gabb, 1869:203, pl. 33, figs. 103b–d; pl. 34, figs. 103, 103a. Waring, 1917:78–79, pl. 13, fig. 10. Hanna, 1927:276, pl. 30, figs. 1–2; pl. 31, figs. 3–4. Stewart, 1930:126–127, pl. 8, fig. 3; pl. 17, fig. 1. Vokes, 1935:291–304, pl. 22–24. Merriam and Turner, 1937:table 2. Turner, 1938:46, pl. 6, fig. 9. Weaver, 1943:78–79, pl. 15, fig. 5. Givens, 1974:44. Givens and Kennedy, 1979:tables 2, 4. Not *Ostrea haleyi* Hertlein, 1933:277–282, pl. 18, figs. 5–6.

Primary Type Material. MCZ lectotype 15048, Domengine Formation, about 3 km east of the Hacienda at New Idria, N ½ of section 15, T 17 S, R 12 E, Priest Valley quadrangle, San Benito County, California.

Molluscan Stage Range. “Capay” through “Tejon.”

Geographic Distribution. San Diego, California through western Washington.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 444, 458, 468a, 478, 485, 548.

Remarks. Ostreid fragments occur at localities 502, 503, and 542 in the interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies, but generic identifications could not be made. Similarly, ostreid fragments occur at localities 463 and 526 in the lower part of the shallow-marine (transgressive) facies, but generic identifications could not be made. Ostreid fragments and single valves of *O. idriaensis* are fairly common in the uppermost part of the “Stewart bed.” The figured specimen (Fig. 10l) is one of the largest specimens.

Subclass Heterodonta

Order Veneroida

Superfamily Lucinacea

Family Lucinidae Fleming, 1828

Subfamily Milthinae Chavan, 1969

Genus *Claibornites* Stewart, 1930

Type Species. By original designation, *Lucina rotunda* Lea, 1833.

Claibornites diegoensis (Dickerson, 1916)

Figure 10m

Lucina diegoensis Dickerson, 1916:484, pl. 37, figs. 1a–b. *Claibornites diegoensis* (Dickerson). Givens, 1974:45–46, pl. 1, fig. 15.

Primary Type Material. UCMP holotype 11788, Ardath Shale, UCMP locality 2226.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. San Diego through Pine Mountain area, southern California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 445.

Remarks. At locality 374, only two single valves were found. An articulated specimen was found at locality 445.

6568, CSUN loc. 475, ×1. **g.** *Pinna llajasensis* Squires, 1983a, internal mold of right valve, UCLA holotype 59196, CSUN loc. 458, ×0.5. **h and i.** *Nayadina (Exputens) llajasensis* (Clark, 1934). All parts from CSUN loc. 374. **h**, right valve, LACMIP topotype and hypotype 6569, ×1. **i**, hinge line, LACMIP topotype and hypotype 6570, ×1.4. **j.** *Spondylus carlosensis* Anderson, 1905, left valve, LACMIP hypotype 6571, CSUN loc. 374, ×1. **k.** *Anomia mcgoniglenensis* Hanna, 1927, right valve, UCLA hypotype 59280, CSUN loc. 438, ×1.5. **l.** *Ostrea idriaensis* Gabb, 1869, left valve, LACMIP hypotype 6572, CSUN loc. 458, ×0.5. **m.** *Claibornites diegoensis* (Dickerson, 1916), right valve, UCLA hypotype 59281, CSUN loc. 374, ×1. **n and o.** *Venericardia (Pacifcor) hornii calafia* Stewart, 1930. All parts from CSUN loc. 374 and ×0.5. **n**, left valve, LACMIP topotype and hypotype 6573. **o**, right valve hinge line, LACMIP topotype and hypotype 6574. **p.** *Venericardia (Pacifcor) aragonia joaquinensis* (Vokes, 1939), UCMP hypotype 37433, UCMP loc. 7193 = CSUN loc. 702, ×1. **q and r.** *Glyptoactis domingenica* (Vokes, 1939), LACMIP hypotype 6575, CSUN loc. 371, ×2.5. **q**, left valve exterior. **r**, left valve interior.

Superfamily Carditacea

Family Carditidae Fleming, 1820

Subfamily Venericardiinae Chavan, 1969

Genus *Venericardia* Lamarck, 1801

Type Species. By subsequent designation (Schmidt, 1818), *Venericardia imbricata* Lamarck, 1801.

Subgenus *Pacificor* Verastegui, 1953

Type Species. By original designation, *Venericardia (Pacificor) mulleri* Verastegui, 1953.

Venericardia (Pacificor) hornii calafia Stewart, 1930

Figures 10n–o

Venericardia hornii calafia Stewart, 1930:168–170, pl. 11, fig. 2. Turner, 1938:50, pl. 14, fig. 4. Weaver, 1943:134–135, pl. 28, figs. 6–7; pl. 31, figs. 4–5.

Venericardia (Pacificor) calafia Stewart. Verastegui, 1953: 28–30, pl. 15, figs. 3–5, 7; pl. 16, figs. 1–3; pl. 17, figs. 1–2.

Venericardia (Pacificor) hornii calafia Stewart. Givens, 1974: 47, pl. 4, fig. 1. Saul, 1983:74, 76, pl. 2, figs. 9, 16–17.

Primary Type Material. UCMP holotype 31450, Llajas Formation, UCMP locality 7004 = CSUN locality 374.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 445, 451, 458, 494, 548, 704.

Remarks. A growth series of this taxon was found at locality 374. At this locality, most of the specimens are single valves, but there are several well-preserved, large-sized articulated specimens. At locality 548, only a single articulated juvenile was found.

Saul (1983) considered *V. (P.) oregonensis* Verastegui from the Lookingglass Formation of southwestern Oregon to be an immature *V. (P.) hornii calafia*. *V. (P.) hertleini* Verastegui is also probably *V. (P.) hornii calafia* (Saul, 1984, pers. commun.).

Venericardia (Pacificor) aragonia *joaquinensis* (Vokes, 1939)

Figure 10p

Venericardia aragonia var. Turner, 1938:49, pl. 13, figs. 6–9.

Megacardita (Venericor) hornii joaquinensis Vokes, 1939: 69–70, pl. 8, figs. 1–2; pl. 9, figs. 1–2.

Venericardia (Leuroactis) schencki Verastegui, 1953:50–51, pl. 4, figs. 6–8.

Venericardia (Leuroactis) alisoensis Verastegui, 1953:52–53, pl. 10, figs. 1–3.

Venericardia (Leuroactis) joaquinensis (Vokes). Verastegui, 1953:60–61, pl. 11, figs. 1–4; pl. 12, figs. 4–6.

Venericardia (Leuroactis) vokesi Verastegui, 1953:61–62, pl. 14, figs. 1–3.

Venericardia (Pacificor) aragonia joaquinensis (Vokes). Saul, 1983:pl. 2, figs. 7–8.

Primary Type Material. UCMP holotype 15616, Avenal Formation, UCMP locality 4170; UCMP paratype 15617, Avenal Formation, UCMP locality 4169; UCMP paratype 15618, Avenal Formation, UCMP locality A-819.

Molluscan Stage Range. Uppermost “Capay” through “Domengine.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 452, 700, 702, 706.

Remarks. Most specimens in the Llajas Formation are fragments of single valves. Extraction of identifiable specimens from the rock is usually difficult. At locality 700, only a single juvenile was found.

The synonymy of this taxon is based on work by Saul (1984, pers. commun.). *V. (P.) a. smileyi* (Vokes) may be conspecific with *V. (P.) a. joaquinensis*, but more taxonomic work is needed to resolve the matter (Saul, 1984, pers. commun.).

The figured specimen (Fig. 10p) is UCMP hypotype 37433 from UCMP locality 7193 = CSUN locality 702. It is the same specimen as used by Saul (1983, pl. 2, fig. 8).

Verastegui (1953) reported *V. (L.) schencki* from the Santa Susana Formation, but his vague locality information makes it impossible to know exactly where he collected his specimens.

The presence of *V. (P.) a. joaquinensis* in the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine (transgressive) facies of the Llajas Formation refines the lower limit of the molluscan stage range of this taxon as uppermost “Capay.”

Subfamily Carditesinae Chavan, 1969

Genus *Glyptoactis* Stewart, 1930

Type Species. By original designation, *Venericardia hadra* Dall, 1903.

Subgenus *Glyptoactis* s.s.

Glyptoactis (Glyptoactis) domenginica (Vokes, 1939)

Figures 10q–r

Venericardia (Glyptoactis?) domenginica Vokes, 1939:66, pl. 5, figs. 7–9.

Venericardia (Glyptoactis) domenginica Vokes. Verastegui, 1953:43–44, pl. 13, fig. 1.

Glyptoactis domenginica (Vokes). Givens, 1974:47. Squires, 1977:table 1. Givens and Kennedy, 1979:tables 1, 3.

Primary Type Material. UCMP holotype 15611, Domengine Formation, UCMP locality A-1219; UCMP paratypes 15612–15613, Tejon Formation, UCMP locality A-1003.

Molluscan Stage Range. “Domengine” through “Transition.”

Geographic Distribution. San Diego through Mt. Diablo, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 507, 518, 529a.

Remarks. This taxon is confined to the shallow-marine (transgressive) facies of the Lajas Formation. Specimens are most abundant at locality 371 where there is a growth series. Preservation is excellent, showing the angular nodes on the ribs. No articulated specimens were found.

This species is placed in the subgenus *Glyptoactis* s.s. because the radial ribs are not tripartite. It is the oldest species of this subgenus.

Superfamily Crassatellacea

Family Crassatellidae Férussac, 1822

Subfamily Crassatellinae Férussac, 1822

Genus *Crassatella* Lamarck, 1799

Type Species. By subsequent designation (Schmidt, 1818), *Macra cygnaea* Lamarck, 1799 (not Chemnitz, 1782) [= *C. gibba* Lamarck, 1801, = *Venus ponderosa* Gmelin, 1791].

Crassatella uvasana Conrad, 1855

Figures 11a–g

Crassatella uvasana Conrad, 1855:9; 1857, pl. 2, fig. 5. Gabb, 1864:214–215, pl. 32, fig. 284. Stewart, 1930:141–143, pl. 12, fig. 9. Turner, 1938:47–48. Givens, 1974:48.

Crassatella alta Conrad, 1855:9; 1857:321 [not Conrad, 1832:21, fig. 7].

Crassatella grandis Gabb, 1864:181, pl. 24, fig. 163; 1869:189.

Astarte semidentata Cooper, 1894:48, pl. 3, figs. 44–45.

Crassatellites grandis (Gabb). Arnold, 1910:13, pl. 2, figs. 10, 10a, pl. 3, fig. 14. Dickerson, 1915:80, pl. 1, fig. 8; pl. 2, figs. 1a–b [not Waring, 1917:74, pl. 12, fig. 16 = *Crassatella branneri* fide Nelson, 1925:410].

Crassatellites uvasana (Conrad). Arnold and Hannibal, 1913:569. Dickerson, 1915:80, pl. 2, fig. 2. Waring, 1917:59, pl. 8, fig. 10.

Crassatellites mathewsonii (Gabb). Dickerson, 1916:pl. 36, figs. 9a–b (probably *C. semidentata* (Cooper) fide Turner, 1938:47–48).

Crassatellites uvasanus (Conrad). Anderson and Hanna, 1925:172–174, pl. 4, figs. 2–3, text figure 7.

Crassatellites semidentata (Cooper). Hanna, 1927:282, pl. 35, figs. 1–2.

Crassatella semidentata (Cooper). Turner, 1938:47–48.

Crassatella uvasana semidentata (Cooper). Vokes, 1939:64–65, pl. 4, figs. 4, 6, 8, 10, 12. Givens, 1974:48. Squires, 1977:table 1. Givens and Kennedy, 1979:tables 1, 3.

Crassatella uvasana uvasana (Conrad). Givens and Kennedy, 1979:table 4.

Primary Type Material. Holotype undetected, USNM collection, Tejon Formation, Grapevine Canyon, Tejon quadrangle, Kern County, California.

Molluscan Stage Range. “Domengine” through “Tejon.”

Geographic Distribution. San Diego through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 444, 445, 447, 458, 471c, 481, 488, 494. Outer shelf and slope channel: CSUN locality 541.

Remarks. Ninety-six specimens were found, and most occur as single valves. Twelve specimens are articulated. A single, abraded fragment was found at the base of a turbidite-filled channel at locality 541. Numerous well-preserved specimens of *C. uvasana* occur in the “Stewart bed” at localities 374 and 444. Heights range from 20 to 90 mm at locality 374 and from 20 to 65 mm at locality 444. There is a growth series at both localities. Many of the juvenile specimens and a few of the adult specimens are articulated at both localities. For the disarticulated specimens, the ratio of right valves to left valves is approximately 1:1. Based on criteria listed by Fagerstrom (1964), the *C. uvasana* specimens at these “Stewart bed” localities are clearly *in situ*.

There is a gradual change in the external appearance of the shells from juvenile to adult individuals at these localities (Figs. 11a–c). The juvenile specimens have higher and more prominent beaks, a less deep lunule, a less steep posterior dorsal slope, a more concave anterior dorsal margin, and a less obvious escutcheon on the left valve. The adult specimens have a more triangular shape and lower, more rounded beaks. The escutcheon on the right valve is much larger than that on the left. Intermediate-sized specimens (with a height of about 45 mm) are transitional between the two.

The comarginal ribbing is identical in both the juvenile and adult specimens. There are numerous very fine, closely spaced comarginal ribs. At regular intervals there are comarginal rugae. Upon decortication, especially in the beak areas, shell between the rugae has a tendency to chip off, leaving depressed areas outlined by the rugae. Only the adult specimens show cancellate sculpture along the ventral margins of the valves.

Interior shell features of juvenile and adult specimens of *C. uvasana* are identical (Figs. 11d–g). The resilifer extends halfway to the lower margin of the hinge plate and the pit is large. The anterior muscle scar is reniform, and the pallial line is deeply impressed. In both juvenile and adult specimens the right valve has the following features: anterior ventral margin of the hinge plate tends to be swollen and fits into a socket in the left valve; anterior cardinal is large, wedge-shaped, vertically below the beak, its upper end margining part of the resilifer; the floor of the lunule tends to wrap around the anterior cardinal in some specimens (Fig. 11f); posterior cardinal is weak; edge of the escutcheon is swollen and projects as a long ridge that fits into a socket in the left valve.

In both juvenile and adult specimens of *C. uvasana*, the left valve has the following features: posterior ventral margin of the hinge plate is slightly swollen; anterior and posterior cardinals are about equal in size; floor of lunule tends to wrap

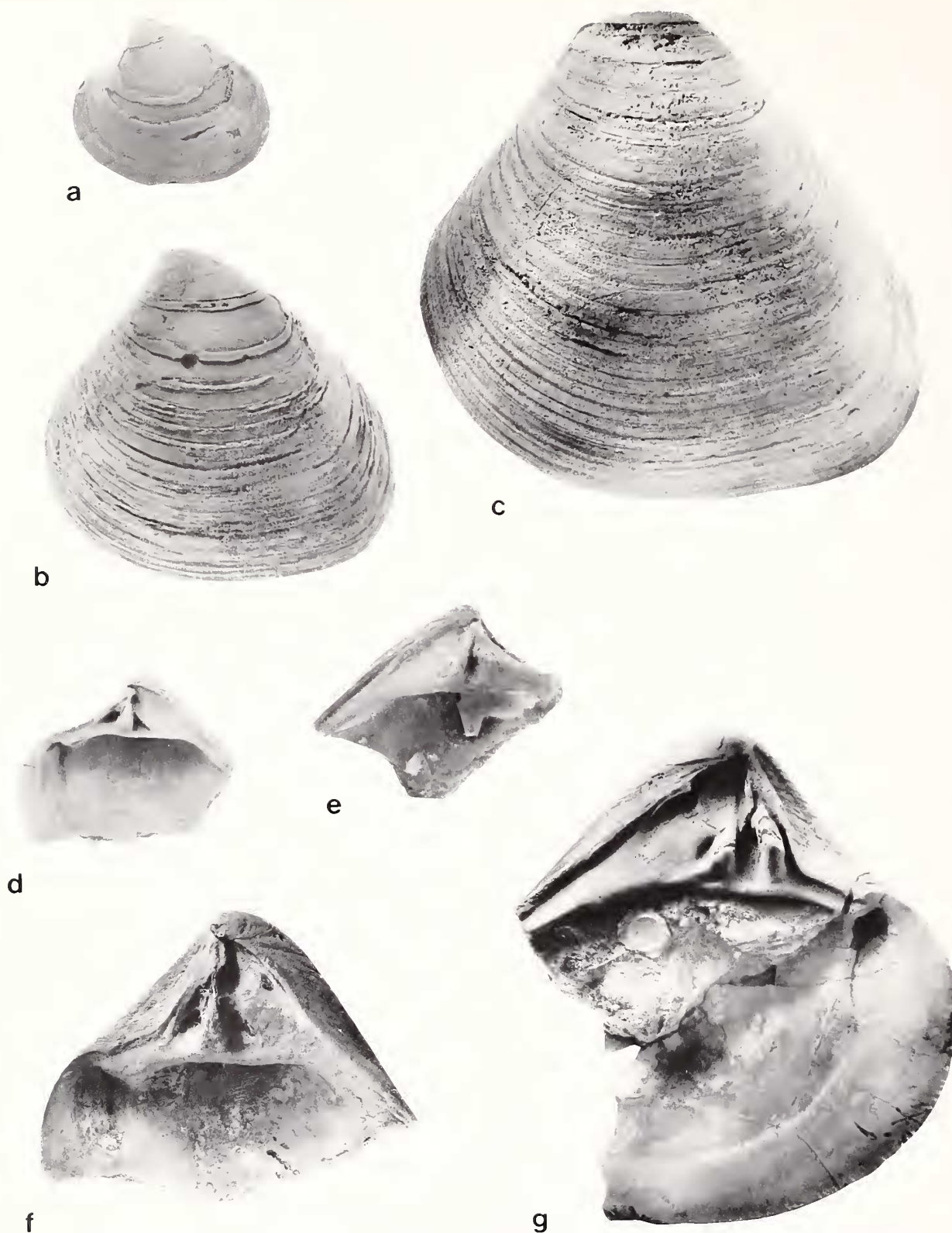


Figure 11. Lajas Formation bivalves (continued). **a through g.** *Crassatella uvasana* Conrad, 1855. All parts from CSUN loc. 374. **a**, left valve, LACMIP hypotype 6576, $\times 1$. **b**, left valve, LACMIP hypotype 6577, $\times 1$. **c**, left valve, LACMIP hypotype 6578, $\times 1$. **d**, right valve interior of juvenile, LACMIP hypotype 6579, $\times 1$. **e**, left valve hinge line of juvenile, LACMIP hypotype 6580, $\times 1.5$. **f**, right valve hinge line of adult, LACMIP hypotype 6581, $\times 1$. **g**, left valve interior of adult, LACMIP hypotype 6582, $\times 1$.

around the anterior cardinal in some specimens, ventral margin of lunule tends to be swollen. In the left valve, as well as in the right valve, the posterior part of the hinge plate is largely occupied by a smooth surface without hinge structures.

If it had not been for the presence of a growth series, the juvenile specimens of *C. uvasana* would have been identified as *C. uvasana semidentata* (Cooper), and the adult specimens would have been identified as *C. uvasana*. Based on the transition of shell characters from the juvenile and adult, as well as the identical shell characters mentioned above, it is concluded that *C. uvasana semidentata* is an unjustified subspecies.

According to Hanna (1927) and Givens (1974), the nature of the beaks is the main distinguishing character between *C. uvasana* and *C. uvasana semidentata*. In actuality, this character can be used to distinguish juvenile from adult specimens of *C. uvasana* as the beaks become more incurved with age. It is interesting to note that if a juvenile specimen is placed on a flat surface, viewed laterally, and elevated along the venter (simulating additional shell material), the beak area then looks identical to that of an adult specimen.

The molluscan stage range of *C. u. semidentata* had been reported as "Domengine" through "Transition" and that of *C. uvasana* as "Tejon" (Givens, 1974). Because the two taxa are identical, the molluscan stage range of *C. uvasana* can be extended to "Domengine" through "Tejon."

Superfamily Cardiacea

Family Cardiidae Lamarck, 1809

Subfamily Cardiinae Lamarck, 1809

Genus *Acanthocardia* Gray, 1851

Type Species. By subsequent designation (Stoliczka, 1870), *Cardium aculeatum* Linné, 1758.

Subgenus *Schedocardia* Stewart, 1930

Type Species. By original designation, *Cardium hatchetigense* Aldrich, 1886.

Acanthocardia (*Schedocardia*) *brewerii* (Gabb, 1864)

Figures 12a–b

Cardium brewerii Gabb, 1864:173, pl. 24, fig. 155. Arnold, 1907:pl. 39, fig. 5. McLaughlin and Waring, 1915:fig. 14. Waring, 1917:pl. 14, fig. 9. Anderson and Hanna, 1925:165–166, pl. 1, fig. 3. Clark, 1929:pl. 12, fig. 7.

Plagiocardium (*Schedocardia*) *brewerii* (Gabb). Stewart, 1930:256–258, pl. 12, fig. 6. Turner, 1938:52–53, pl. 9, figs. 6–7. Vokes, 1939:75, pl. 11, figs. 1–4. Stewart, 1946:pl. 11, fig. 20.

Plagiocardium brewerii (Gabb). Merriam and Turner, 1937:table 2.

Loxocardium (*Schedocardia*) *brewerii* (Gabb). Weaver, 1943:153–154, pl. 35, figs. 15, 16, 18; pl. 38, figs. 1, 9; pl. 104, fig. 12.

Cardium (*Trachycardium*) *brewerii brewerii* (Gabb). Kleinpell and Weaver, 1963:201–202, pl. 34, figs. 1–2.

Acanthocardia (*Schedocardia*) *brewerii* (Gabb). Givens, 1974:48–49, pl. 1, fig. 17.

Acanthocardia brewerii (Gabb). Givens and Kennedy, 1979:table 4.

Primary Type Material. ANSP lectotype 4560, Tejon Formation, east of north end of Grapevine Canyon, Kern County, California.

Molluscan Stage Range. "Capay" through "Tejon."

Geographic Distribution. San Diego, California through southwestern Washington.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN localities 545, 702. Shallow-marine (transgressive) facies: CSUN localities 371, 374, 548, 704.

Remarks. This taxon is somewhat uncommon in the Llajas Formation. It is most common at locality 374 where it occurs as single valves. The largest specimens are also from this locality.

Subfamily Protocardiinae Keen, 1951

Genus *Nemocardium* Meek, 1876

Type Species. By subsequent designation (Sacco, 1899), *Cardium semiasperum* Deshayes, 1858.

Nemocardium linteum (Conrad, 1855)

Figure 12c

Cardium linteum Conrad, 1855:3, 9; 1857:pl. 2, fig. 1. Anderson and Hanna, 1925:166–167, pl. 3, fig. 3.

Cardium cooperii Gabb, 1864:172, pl. 24, figs. 154, 154a. Arnold, 1907:pl. 38, figs. 2–2a. Waring, 1917:pl. 13, fig. 3. Hanna, 1927:285, pl. 41, figs. 6–7.

Cardium dalli Dickerson, 1913:289, pl. 14, figs. 4a–c.

Cardium marysvillensis Dickerson, 1916:482 [new name for *Cardium dalli* Dickerson, 1913, preoccupied].

Cardium (*Protocardium*) *marysvillensis* Dickerson. Clark and Woodford, 1927:94, pl. 15, fig. 12.

Nemocardium linteum (Conrad). Stewart, 1930:275–277, pl. 8, fig. 6. Turner, 1938:52, pl. 10, fig. 10. Vokes, 1939:76–77, pl. 11, figs. 6, 9. Weaver, 1943:159–160, pl. 38, fig. 3; 1953:28. Stewart, 1946:pl. 11, fig. 19. Zinsmeister, 1974:97–98, pl. 9, figs. 7–9; 1983a:pl. 2, fig. 7. Givens and Kennedy, 1979:table 4.

Cardium (*Nemocardium*) *linteum* Conrad. Kleinpell and Weaver, 1963:202, pl. 34, fig. 4.

Nemocardium (*Nemocardium*) *linteum* (Conrad). Givens, 1974:49. Squires, 1977:table 1.

Primary Type Material. USNM holotype 1834, Domengine Formation, near Martinez, California.

Molluscan Stage Range. "Martinez" through "Tejon."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 373, 374, 438, 444, 445, 458, 479, 488, 493, 513, 525, 548.

Remarks. This taxon is most common in the upper part of the shallow-marine (transgressive) facies. At locality 438, six specimens were found, one of which was articulated. In the "Stewart bed" at locality 374, 21 specimens were found and one was articulated.

Superfamily Solenacea

Family Solenidae Lamarck, 1809

Genus *Solena* Mörch, 1853

Type Species. By subsequent designation (Stoliczka, 1871), *Solen obliquus* Spengler, 1794.

Subgenus *Eosolen* Stewart, 1930

Type Species. By original designation, *Solen plagiaulax* Cossmann, 1906.

Solena (Eosolen) novacularis (Anderson and Hanna, 1928)

Figure 12d

Solen novacula Anderson and Hanna, 1925:147, pl. 6, fig. 9.
Hanna, 1927:294, pl. 43, fig. 1.

Not *Solen novacula* Montagu, 1803:47.

Solen novacularis Anderson and Hanna, 1928:65–66 [new name for *Solen novacula* Anderson and Hanna, 1925, preoccupied].

Solena (Eosolen) coosensis Turner, 1938:62–63, pl. 9, figs. 1–2. Vokes, 1939:96, pl. 15, fig. 5. Givens, 1974:49–50, pl. 2, fig. 1.

Solena coosensis Turner. Weaver, 1943:229, pl. 52, fig. 16; pl. 53, fig. 13.

Solena novacularis (Anderson and Hanna). Givens and Kennedy, 1979:table 4.

Primary Type Material. CAS holotype 882 of *Solen novacula* Anderson and Hanna and of *Solen novacularis* Anderson and Hanna, Tejon Formation, CAS locality 792.

Molluscan Stage Range. Uppermost "Capay"?, "Domengine" through "Tejon."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 701? Shallow-marine (transgressive) facies: CSUN localities 374, 444, 445, 449, 458, 477, 494, 500.

Remarks. This species helps to characterize the "Stewart bed." At many localities of the "Stewart bed," and especially at locality 374, specimens are fairly common and many are articulated. A solenid at locality 701 may be this species.

A previously assigned "Capay" age (Turner, 1938; Givens, 1974) for the lower range limit of this species was based on occurrence in the "upper Umpqua" Formation of southwestern Oregon. The "upper Umpqua," however, is actually equivalent to both the "Capay" and "Domengine" "Stages" (Baldwin, 1974; Miles, 1981). A lower range limit of uppermost "Capay," nevertheless, is apparent because of the possible occurrence of this species in the zone of interfingering

between the coastal alluvial-fan facies and the shallow-marine (transgressive) facies of the Lajas Formation.

Superfamily Tellinacea

Family Tellinidae Blainville, 1814

Subfamily Macominae Olsson, 1961

Genus *Macoma* Leach, 1819

Type Species. By monotypy, *Macoma tenera* Leach, 1819 [= *Tellina calcarea* Gmelin, 1791].

Macoma rosa Hanna, 1927

Figure 12e

Macoma rosa Hanna, 1927:292, pl. 41, figs. 2–5, 8. Clark, 1929:pl. 6, fig. 15. Givens and Kennedy, 1979:table 1.

Primary Type Material. UCMP holotype 31094, Ardath Shale, UCMP locality 3993; UCMP paratype 31095, Ardath Shale, UCMP locality 5089; UCMP paratypes 31096–31097, Ardath Shale, UCMP locality 5085.

Molluscan Stage Range. "Domengine."

Geographic Distribution. San Diego through Simi Valley, California.

Local Occurrence. Shallow-marine (regressive) facies: CSUN localities 462, 489, 512a, 512d, 544.

Remarks. This taxon helps to characterize the shallow-marine (regressive) facies. Specimens are usually few in number and preserved as external and internal molds of articulated individuals.

Family Psammobiidae Fleming, 1828

Subfamily Psammobiinae Fleming, 1828

Genus *Gari* Schumacher, 1817

Type Species. Pending decision by the ICZN, *Gari vulgaris* Schumacher, 1817 (= *Solen amethystus* Wood, 1818).

Gari cf. *G. eoundulata* Vokes, 1939

Figure 12f

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 471d.

Remarks. Specimens are relatively rare in the Lajas Formation. They are preserved as internal molds of single valves, making species identification impossible.

Superfamily Veneracea

Family Veneridae Rafinesque, 1815

Subfamily Pitarinae Stewart, 1930

Genus *Callista* Poli, 1791

Type Species. By subsequent designation (Meek, 1876), *Venus chione* Linné, 1758.

Subgenus *Costacallista* Palmer, 1927

Type Species. By original designation, *Venus erycina* Linné, 1758.

Callista (*Costacallista*) cf.
C. (C.) hornii (Gabb, 1864)

Figure 12g

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 373, 465, 466, 467, 704.

Remarks. A few specimens were found as single valves. Hinge-line details were imperfectly preserved, hence a certain species identification could not be made.

Genus *Callocardia* A. Adams, 1864

Type Species. By monotypy, *Callocardia guttata* A. Adams, 1864.

Subgenus *Nitidavenus* Vokes, 1939

Type Species. By original designation, *Cytherea nitida* Deshayes, 1858.

Callocardia (*Nitidavenus*) *tejonensis*
(Waring, 1914)

Figure 12h

Isocardia tejonensis Waring, 1914:784–785; 1917:93, pl. 15, fig. 14.

cf. “*Isocardia tejonensis*” Waring. Turner, 1938:58, pl. 11, figs. 1–4.

Nitidavenus tejonensis (Waring). Vokes, 1939:83–84, pl. 12, figs. 11, 13–16.

Primary Type Material. SU holotype 189, SU paratypes 5188–5190, Llajas Formation, SU locality 2696.

Molluscan Stage Range. “Capay” through “Domengine.”

Geographic Distribution. Simi Valley, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 372.

Remarks. Only four single valves were found in the Llajas Formation.

Genus *Pitar* Römer, 1857

Type Species. By monotypy, *Venus tumens* Gmelin, 1791.

Subgenus *Calpitaria* Jukes-Browne, 1908

Type Species. By original designation, *Cytherea sulcataria* Deshayes, 1824.

Pitar (*Calpitaria*) *uvasanus* (Conrad, 1855).

Figures 12i–j

Meretrix uvasana Conrad, 1855:9; 1857:pl. 2, fig. 3. Gabb, 1864:163–164, pl. 30, fig. 248.

Meretrix tejonensis Dickerson, 1915:53–54, pl. 3, figs. 3a–b, not 2a–b. [Unjustified new name for *Meretrix uvasana* Conrad of Gabb, 1864, *vide* Anderson and Hanna, 1925:160–161 and Stewart, 1930:236.]

Not *Pitaria tejonensis* (Dickerson). Anderson and Hanna, 1925:160–161, pl. 3, fig. 5.

Pitaria uvasana (Conrad). Anderson and Hanna, 1925:161, pl. 5, figs. 3–4.

Pitar (*Calpitaria*) *uvasanus* (Conrad). Stewart, 1930:235–236, pl. 12, fig. 7. Weaver, 1943:178–179, pl. 47, fig. 13. Givens, 1974:53.

Pitar uvasanus uvasanus (Conrad). Givens and Kennedy, 1979:tables 3–4.

Primary Type Material. ANSP neotype 4457, Tejon Formation, Grapevine Canyon, Kern County, California.

Molluscan Stage Range. “Domengine” through “Tejon.”

Geographic Distribution. San Diego, California through western Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 371, 374.

Remarks. Specimens are fairly uncommon and generally consist of fragments of single valves. The occurrence of this taxon in the Llajas Formation extends its range into the “Domengine Stage.” Previously, it had been reported as ranging from the “Transition” through the “Tejon” (Givens, 1974).

Meretrix tejonensis Dickerson, 1915:53, pl. 3, figs. 2a–b = *Pitar* (*Lamelliconcha*) *dickersoni* Givens, *vide* Givens, 1974:53–54.

Subgenus *Lamelliconcha* Dall, 1902

Type Species. By original designation, *Cytherea concinna* J. Sowerby, 1835a.

Pitar (*Lamelliconcha*) *joaquinensis*

Vokes, 1939

Figure 12k

Meretrix hornii Gabb. Arnold, 1910:pl. 3, fig. 9. [Misidentification.]

Pitar (*Lamelliconcha*) *joaquinensis* Vokes, 1939:85–86, pl. 13, figs. 9–12. Givens, 1974:54, pl. 3, fig. 7.

Pitar? *joaquinensis* Vokes. Stewart, 1946:pl. 12, fig. 12.

Pitar joaquinensis Vokes. Givens and Kennedy, 1979:table 1.

Primary Type Material. UCMP holotype 15674, Domengine Formation, UCMP locality A-1027; UCMP paratype 15675, Domengine? Formation, UCMP locality 4175; UCMP paratype 15676, Domengine Formation, UCMP locality A-1027; UCMP paratype 15677, Avenal Formation, UCMP locality A-1280.

Molluscan Stage Range. “Domengine.”

Geographic Distribution. Simi Valley through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371.

Remarks. Only a few single valves were found in the Llajas Formation.

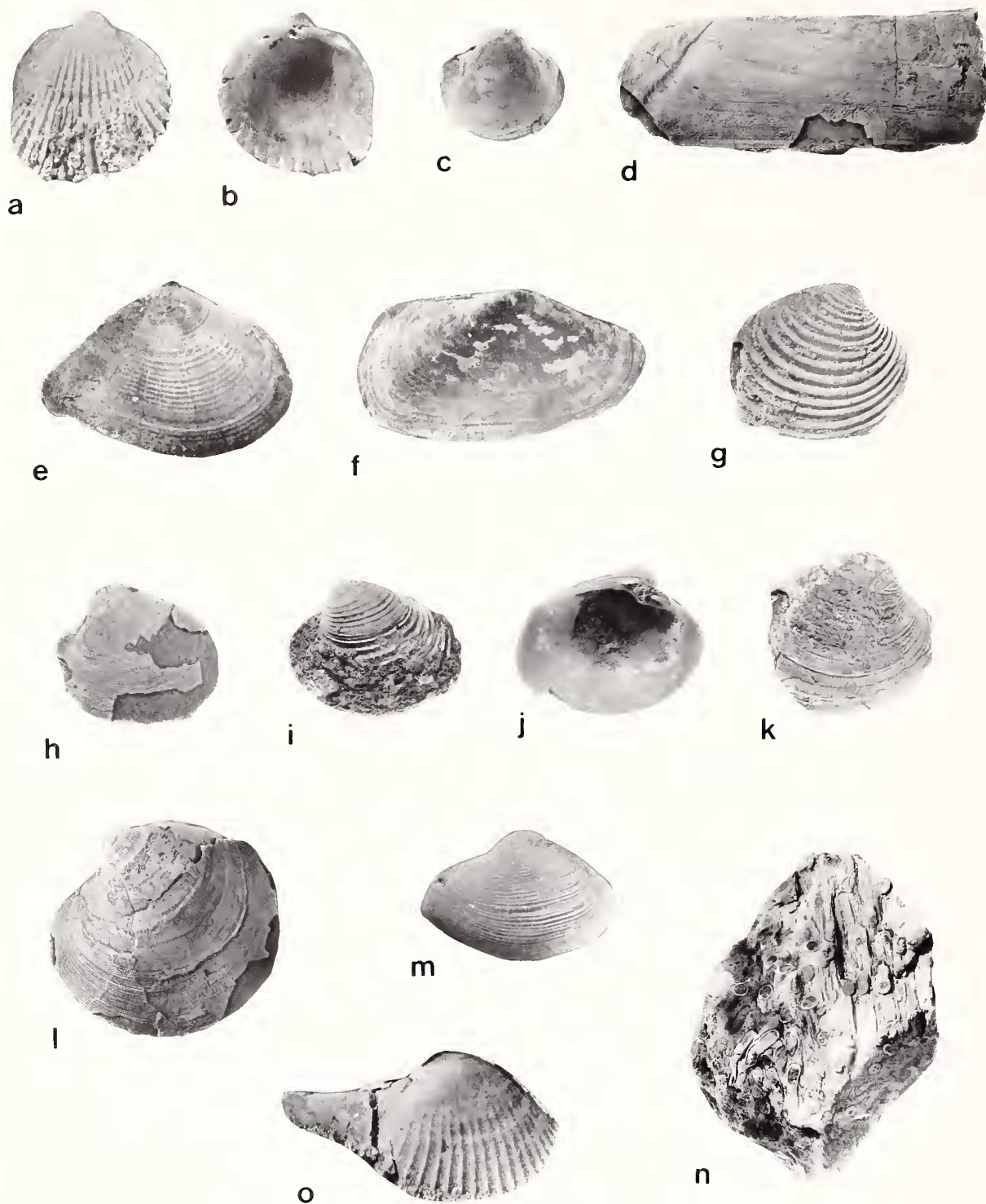


Figure 12. Lajas Formation bivalves (continued). **a and b.** *Acanthocardia* (*Schedocardia*) *breweri* (Gabb, 1864), right valve, LACMIP hypotype 6583, CSUN loc. 371, $\times 2$. **a.** exterior. **b.** interior. **c.** *Nemocardium* *lenteum* (Conrad, 1855), internal mold of right? valve, LACMIP hypotype 6584, CSUN loc. 374, $\times 1$. **d.** *Solena* (*Eosolen*) *novacularis* (Anderson and Hanna, 1928), left valve, LACMIP hypotype 6585, CSUN loc. 374, $\times 1$. **e.** *Macoma* *rosa* Hanna, 1927, internal mold of right valve, LACMIP hypotype 6586, CSUN loc. 489, $\times 1.5$. **f.** *Gari* cf. *G. eoundulata* Vokes, 1939, internal mold of right valve, LACMIP hypotype 6587, CSUN loc. 471d, $\times 1$. **g.** *Callista* (*Costacallista*) cf. *C. (C.) hornii* (Gabb, 1864), right valve, LACMIP hypotype 6588, CSUN loc. 465, $\times 2$. **h.** *Callocardia* (*Nitidavenus*) *tejonensis* (Waring, 1914), left valve, LACMIP

Subfamily Tapetinae H. and A. Adams, 1857

Genus *Marcia* H. and A. Adams, 1857

Type Species. By subsequent designation (Kobelt, 1883), "*Venus pinguis* Chemnitz" [= *V. opima* Gmelin, 1791].

Subgenus *Mercimonia* Dall, 1902

Type Species. By original designation, *Venus bernayi* Cossmann, 1888.

Marcia (Mercimonia) bunker (Hanna, 1927)

Figure 12l

Dosinia bunker Hanna, 1927:287, pl. 42, figs. 4, 6.

Mercimonia bunker (Hanna). Turner, 1938:60, pl. 10, figs. 5–9. Vokes, 1939:77, pl. 11, fig. 12. Givens and Kennedy, 1979:87, table 3.

Marcia (Mercimonia) bunker (Hanna). Weaver, 1943:192, pl. 45, fig. 5; pl. 47, figs. 8, 11.

Primary Type Material. UCMP holotype 30950, Ardath Shale, UCMP locality 5069; UCMP paratype 30951, Ardath Shale, UCMP locality 3976.

Molluscan Stage Range. "Domengine" through "Transition."

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 374.

Remarks. Only three specimens were found in the Llajas Formation, and of these, two are articulated.

Order Myoida

Suborder Myina

Superfamily Myacea

Family Corbulidae Lamarck, 1818

Subfamily Corbulinae Lamarck, 1818

Genus *Corbula* Bruguière, 1797

Type Species. By subsequent designation (Schmidt, 1818), *Corbula sulcata* Lamarck, 1801.

Subgenus *Caryocorbula* Gardner, 1926

Type Species. By original designation, *Corbula alabamensis* Lea, 1833.

Corbula (Caryocorbula) dickersoni
(Weaver and Palmer, 1922)

Figure 12m

Corbula dickersoni Weaver and Palmer, 1922:24–25, pl. 9, figs. 9–10. Clark, 1938:700, pl. 1, fig. 17. Weaver, 1943:257–258, pl. 61, figs. 13, 16–17, 20.

Corbula (Caryocorbula) dickersoni Weaver and Palmer. Vokes, 1939:98, pl. 16, figs. 1, 5, 9. Givens, 1974:57, pl. 4, fig. 7.

Primary Type Material. CAS holotype 7452, CAS syntypes 7452A–B, Cowlitz Formation, UW locality 329.

Molluscan Stage Range. Uppermost "Capay" through "Tejon."

Geographic Distribution. Simi Valley, California through southwestern Washington.

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 545. Shallow-marine (transgressive) facies: CSUN localities 371, 373, 455, 484, 498, 501, 507, 540. Shallow-marine (regressive) facies: CSUN locality 475.

Remarks. This taxon is most common at locality 371, where the specimens are similar-sized single valves.

The presence of *C. (C.) dickersoni* in the zone of interfingering between the coastal alluvial-fan facies and the shallow-marine (transgressive) facies of the Llajas Formation extends the molluscan stage range of this taxon into the uppermost "Capay." Previously, the lower range limit had been reported as the "Domengine" (Vokes, 1939; Givens, 1974).

Suborder Pholadina

Superfamily Pholadacea

Family Teredinidae Rafinesque, 1815

Subfamily Teredininae Rafinesque, 1815

Genus *Teredo* Linné, 1758

Type Species. By subsequent designation (ICZN, 1926, opin. 94), *Teredo navalis* Linné, 1758.

Teredo? sp.

Figure 12n

Local Occurrence. Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies: CSUN locality 469c. Shallow-marine (transgressive) facies: CSUN localities 374, 438, 444, 469, 470a, 488, 534. Outer shelf and slope

hypotype 6589, CSUN loc. 371, $\times 1$. i and j. *Pitar (Calpitaria) uvasanus* (Conrad, 1855), left valve, LACMIP hypotype 6590, CSUN loc. 371, $\times 1.5$. i, exterior. j, interior. k. *Pitar (Lamelliconcha) joaquinensis* Vokes, 1939, partial specimen, right valve, LACMIP hypotype 6591, CSUN loc. 371, $\times 1$. l. *Marcia (Mercimonia) bunker* (Hanna, 1927), left? valve, UCLA hypotype 59282, CSUN loc. 374, $\times 1$. m. *Corbula (Caryocorbula) dickersoni* (Weaver and Palmer, 1922), right valve, LACMIP hypotype 6592, CSUN loc. 371, $\times 2.75$. n. *Teredo?* sp., in petrified wood, LACMIP hypotype 6593, CSUN locality 524, $\times 0.5$. o. *Cardiomya* aff. *C. russelli* (Hanna, 1927), internal mold of right valve, LACMIP hypotype 6594, CSUN loc. 512d, $\times 4$.

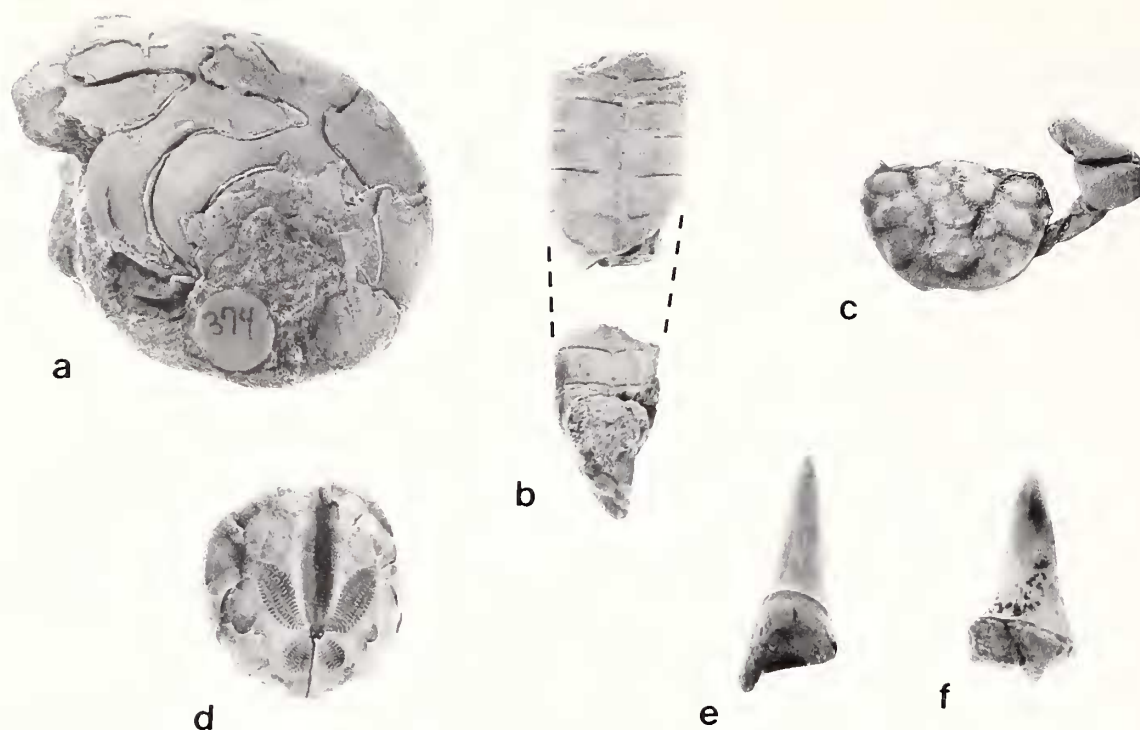


Figure 13. Lajas Formation nautiloid, crab, spatangoid, and shark teeth. **a.** *Aturia myrlae* Hanna, 1927, lateral view, LACMIP hypotype 6595, CSUN loc. 374, $\times 1.75$. **b.** Unidentifiable spirulimorph sepiid, ventral view of partial phragmocone, UCLA hypotype 59197, CSUN loc. 493, $\times 2.6$. **c.** *Glyphithyreus weaveri* (Rathbun, 1926), carapace and portion of right cheliped, dorsal view, UCLA hypotype 59273, CSUN loc. 548, $\times 1$. **d.** *Schizaster diabloensis* Kew, 1920, internal mold, dorsal view, LACMIP hypotype 6596, CSUN loc. 482, $\times 1$. **e.** *Odontaspis* sp., LACMIP hypotype 6597, CSUN loc. 374, $\times 1$. **f.** *Isurus* cf. *I. praecursor* (Leriche, 1906), LACMIP hypotype 6598, CSUN loc. 371, $\times 3$.

facies: CSUN locality 446. Outer shelf and slope channel facies: CSUN locality 541.

Remarks. *Teredo?* sp. occurs in pieces of petrified wood. In most cases, *Teredo?* sp. is represented by calcareous-lined burrows, but unlined burrows can be present in the same piece of wood. Generic determination is uncertain, and it is very possible that future workers will assign these fossils to another genus. Tertiary teredinids are in need of much taxonomic work.

Subclass Anomalodesmata

Order Pholadomyoidea

Superfamily Poromyacea

Family Cuspidariidae Dall, 1886

Genus *Cardiomya* A. Adams, 1864

Type Species. By monotypy, *Neaera gouldiana* Hinds, 1843.

Cardiomya aff. *C. russelli* (Hanna, 1927)

Figure 12o

Local Occurrence. Shallow-marine (regressive) facies: CSUN locality 512d.

Remarks. Only a single specimen was found, and it is an internal mold of a right valve. The specimen agrees closely with the description of *C. russelli* given by Hanna (1927: 280–281) in possessing radial ribs and a long, straight smooth rostrum. The Lajas specimen differs in that it has at least 19 radial ribs rather than 16.

Class Cephalopoda

Subclass Nautiloidea

Order Nautilida

Superfamily Nautilacea

Family Aturiidae Hyatt, 1894

Genus *Aturia* Bronn, 1838

Type Species. By subsequent designation (Herrmannsen, 1846), *Nautilus aturi* Basterot, 1825, and virtual tautonymy.

Aturia myrlae Hanna, 1927

Figure 13a

Aturia myrli Hanna, 1927:331, pl. 57, figs. 1, 6.

Aturia myrlae Hanna. Schenck, 1931:454–456, pls. 67–68; text figures 4-3, 4–19. Vokes, 1939:107, pl. 16, fig. 36.

Miller, 1947:100–101, pl. 76, figs. 2–3; pl. 77, figs. 1–2; pl. 92, figs. 6–7.

Primary Type Material. UCMP holotype 31089, Ardath Shale, UCMP locality 3989.

Molluscan Stage Range. “Capay” through “Domengine.”

Geographic Distribution. San Diego through central California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 458.

Remarks. Specimens were found only in the “Stewart bed.” The best preserved specimens are from locality 374 where one juvenile (Fig. 13a) and an adult specimen were found. As reported by Schenck (1931), a hypotype of *A. myrlae* is from UCMP 7004 = CSUN locality 374.

Subclass Coleoidea

Order Sepiida

Family Indeterminate

Spirulimorph Sepiid

Figure 13b

Spirulimorph sepiid Squires, 1983a:360, figs. 2j–k.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 493.

Remarks. Only a single partial phragmocone and associated external mold were found in the Llajas Formation. In the absence of the rostrum and the apical part of the phragmocone, the specimen and mold are unidentifiable. This is the first sepiid in the Eocene of western North America (Squires, 1983a).

Phylum Arthropoda

Class Malacostraca

Subclass Eumalacostraca

Order Decapoda

Suborder Pleocyemata

Infraorder Brachyura

Section Brachyrhyncha

Superfamily Xanthoidea

Family Goneplacidae MacLeay, 1838

Subfamily Carcinoplacinae

Milne-Edwards, 1852

Genus *Glyphithyreus* Reuss, 1859

Type Species. By original designation, *Glyphithyreus formosus* Reuss, 1859 (= *Plagiolophus wetherelli* Bell, 1858).

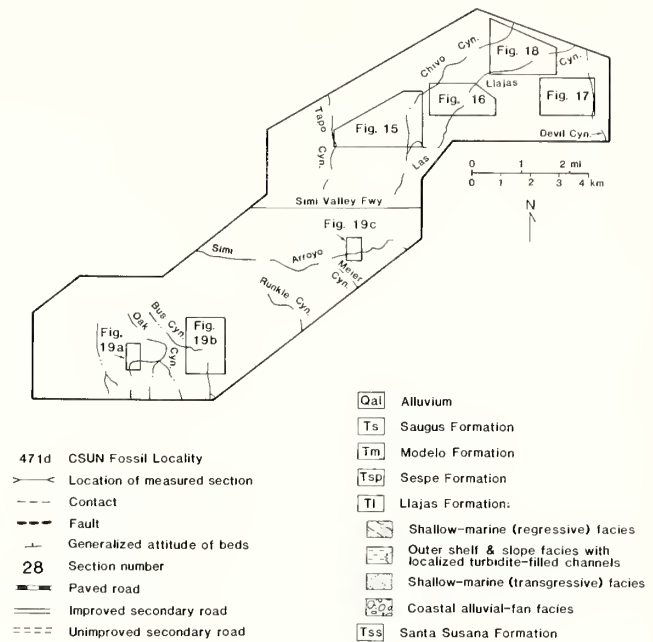


Figure 14. Index map to the Llajas Formation showing locations of areas used as fossil-collecting locality maps in Figures 15–19. An explanation of symbols used on the locality maps is also given.

Glyphithyreus weaveri (Rathbun, 1926)

Figure 13c

Cancer? sp. Weaver, 1905:123, pl. 13, fig. 11.

Cancer (?) sp. A Dickerson, 1916:pl. 42, fig. 11.

Plagiolophus weaveri Rathbun, 1926:35–37, pl. 9, figs. 5–6.

Orr and Kooser, 1971:157, text figure 3a, figs. 4a–c, figs. 5a–i.

Primary Type Material. USNM holotype 353351, Eocene strata, Salt Creek, 5.2 km north-northeast of Joaquin Rocks, south part of NW ¼ of section 15, T 18 S, R 14 E, Fresno County, California.

Molluscan Stage Range. “Capay” through “Domengine.”

Geographic Distribution. San Diego, California through southwestern Oregon.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 471b, 548.

Remarks. Although fragments of brachyuran chelipeds were found at widely scattered localities in the Llajas Formation, carapaces were found only at localities 471b and 548. At locality 548, most of the specimens have also one or both chelipeds intact.

Phylum Echinodermata

Subphylum Echinozoa

Class Echinoidea

Subclass Euechinoidea

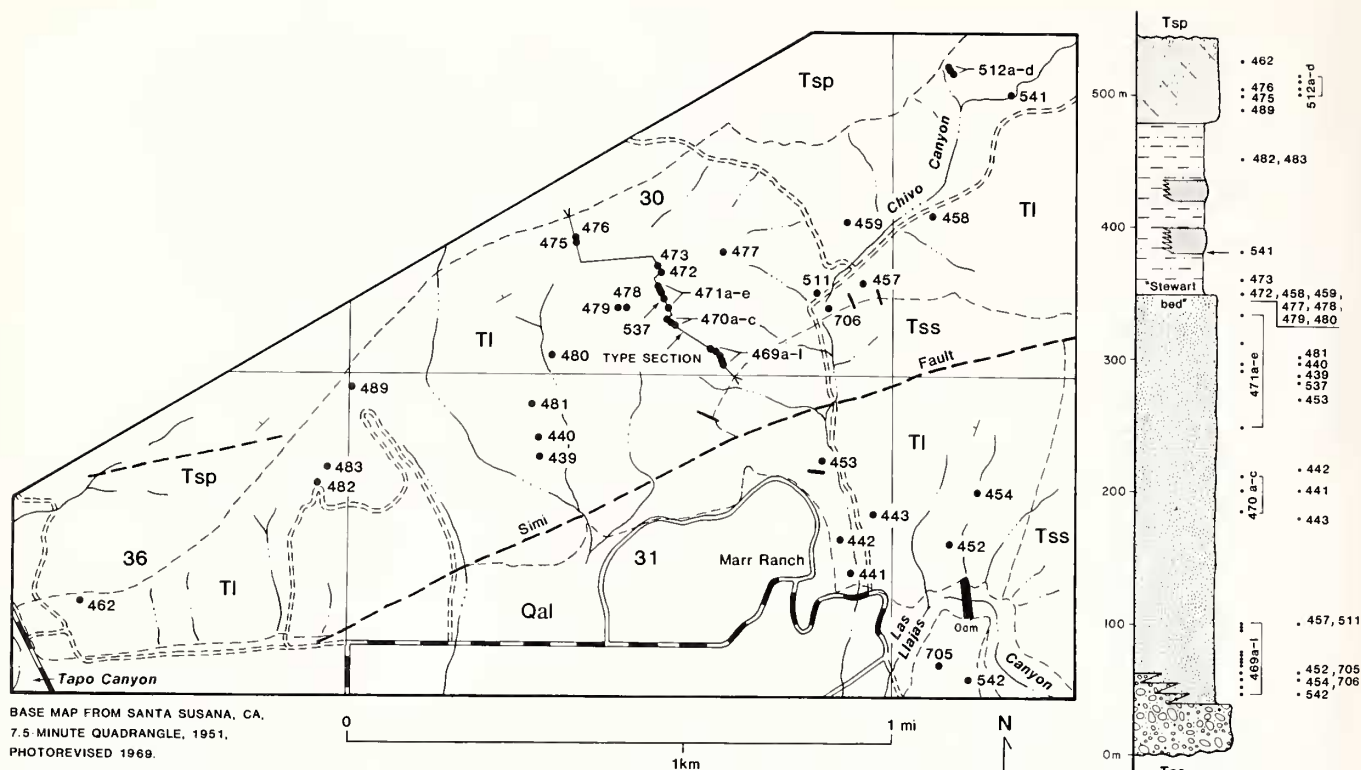


Figure 15. Geologic map showing CSUN fossil-collecting localities, Lajas Formation, type section area. Accompanying columnar section shows stratigraphic position of the fossil-collecting localities. See Figure 14 for explanation of symbols.

Superorder Atelostomata

Order Spatangoida

Suborder Hemiasterina

Family Schizasteridae Lambert, 1902

Genus *Schizaster* L. Agassiz, 1836

Type Species. By subsequent designation (ICZN, 1954, opin. 209), *Schizaster studeri* L. Agassiz, 1836.

Schizaster diabloensis Kew, 1920

Figure 13d

Schizaster diabloensis Kew, 1920:150–151, pl. 41, figs. 5a–c. Clark and Woodford, 1927:123, pl. 22, fig. 14. Clark, 1929:pl. 4, fig. 13. Grant and Hertlein, 1938:120.

Primary Type Material. UCMP holotype 11387, Eocene strata, UCMP locality 1427.

Molluscan Stage Range. Upper Paleocene through “Domengine.”

Geographic Distribution. Simi Valley through Marysville Buttes, California.

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 458, 478. Outer shelf and slope facies: CSUN locality 482. Shallow-marine (regressive) facies: CSUN locality 547.

Remarks. Preservation is as internal molds and most specimens are somewhat crushed. At locality 547, *S. diabloensis* is the only megafossil present.

Clark and Woodford (1927) reported this species from the type section area of the Meganos Formation. Marinovich (1977:251) considered the formation to be late Paleocene in age.

Phylum Chordata

Class Chondrichthyes

Subclass Elasmobranchii

Order Lamniformes

Family Odontaspidae

Müller and Henle, 1837

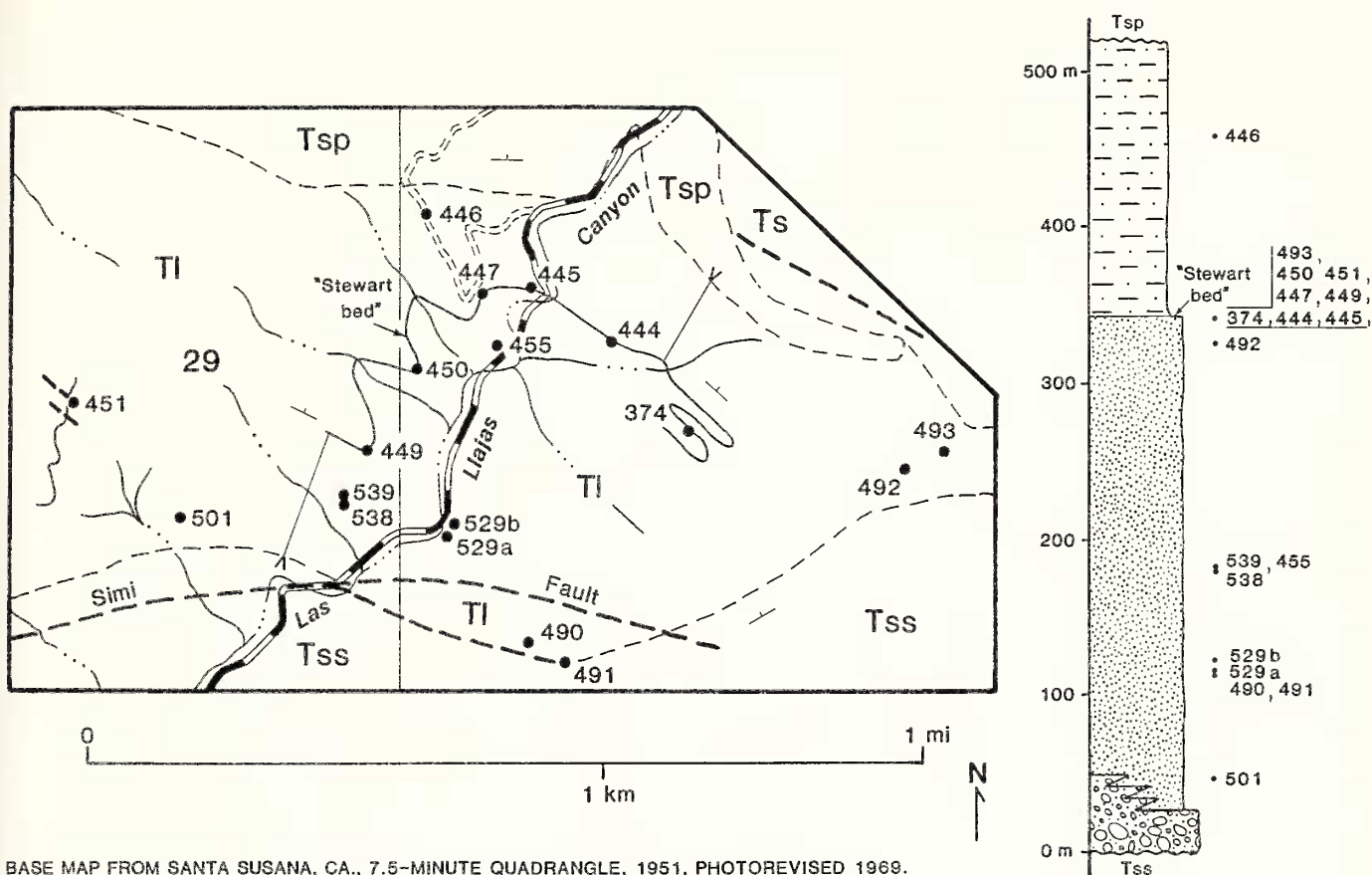
Genus *Odontaspis* L. Agassiz, 1838

Type Species. By monotypy, *Odontaspis ferox* Risso, 1810.

Odontaspis sp.

Figure 13e

Local Occurrence. Shallow-marine (transgressive) facies: CSUN localities 374, 445.



BASE MAP FROM SANTA SUSANA, CA., 7.5-MINUTE QUADRANGLE, 1951, PHOTOREVISED 1969.

Figure 16. Geologic map showing CSUN fossil-collecting localities, Lajas Formation, lower Las Lajas Canyon area. Accompanying columnar section shows stratigraphic position of the fossil-collecting localities. See Figure 14 for explanation of symbols.

Remarks. Only a few specimens were found in the Lajas Formation.

Family Lamnidae Müller and Henle, 1838

Genus *Isurus* Rafinesque, 1809

Type Species. By original designation, *Isurus oxyrinchus* Rafinesque, 1809.

Isurus cf. *I. praecursor* (Leriche, 1906)

Figure 13f

Local Occurrence. Shallow-marine (transgressive) facies: CSUN locality 371.

Remarks. Only one specimen was found in the Lajas Formation.

LOCALITIES

CSUN fossil-collecting localities made by the author in the course of this study are listed first. Localities of other institutions mentioned in this report follow in alphabetical order.

All CSUN localities are in the Lajas Formation, Simi Valley area, California. Unless otherwise noted, they are in the United States Geological Survey 7.5-minute topographic

quadrangle of Santa Susana, California (1951), photorevised 1969. In some cases, a locality is in the Santa Susana quadrangle, but the section corner used for referencing is in the United States Geological Survey 7.5-minute topographic quadrangle of Oat Mountain, California (1952), photorevised 1969. These localities are so noted. Abbreviations used are United States Geological Survey (USGS), feet (ft.), meters (m), township (T), range (R), north (N), south (S), east (E), and west (W). Distances are given in both English and metric units, but map contour elevations are given in English units only.

CSUN localities equivalent to localities of University of California Museum of Paleontology (Berkeley) (UCMP); University of California, Los Angeles (UCLA); and California Institute of Technology (CIT) are so indicated. CSUN localities are denoted also as to which marine facies (Squires, 1981) they belong. The general location and the relative stratigraphic position of each CSUN locality are shown in Figures 14 through 19.

CSUN LOCALITIES

371. At elevation of 2000 ft. on south side of a side canyon to Devil Canyon, 1275 ft. (389 m) south and 1150 ft. (350

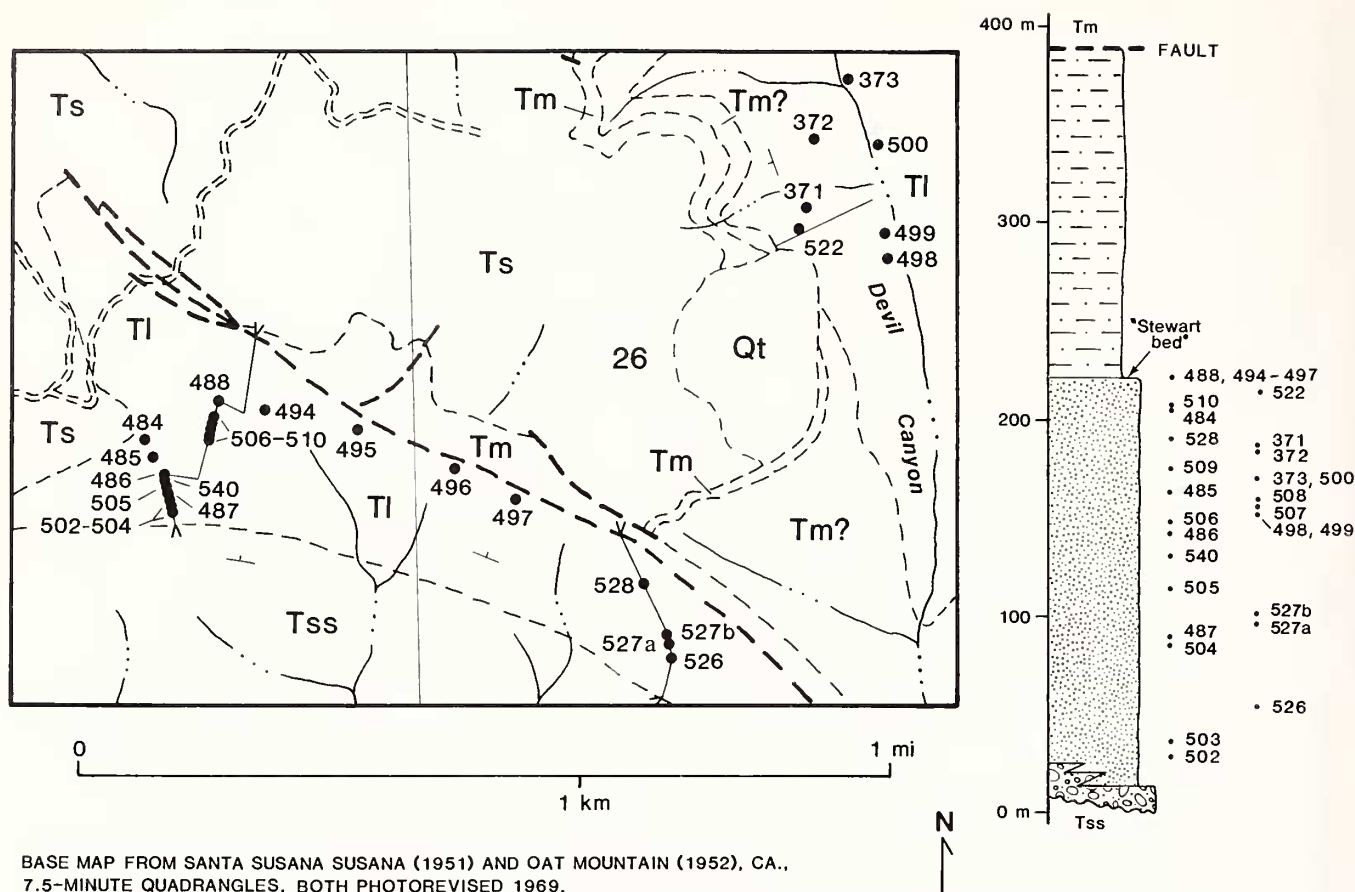


Figure 17. Geologic map showing CSUN fossil-collecting localities, Lajas Formation, Devil Canyon area. Accompanying columnar section shows stratigraphic position of the fossil-collecting localities. See Figure 14 for explanation of symbols.

m) west of NE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

372. At elevation of 2035 ft. on west side of stream bank of Devil Canyon, 800 ft. (244 m) south and 1200 ft. (366 m) west of NE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

373. At elevation of 1900 ft. on east side of stream bank of Devil Canyon, 450 ft. (137 m) south and 850 ft. (259 m) west of NE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

374. At elevation of 1700 ft. on a small cliff on south side of a side canyon to Las Lajas Canyon, 1950 ft. (594 m) north and 1825 ft. (556 m) east of SE corner of section 29, T 3 N, R 17 W. Locality is in the "Stewart bed" and is equivalent to UCMP locality 7004, UCLA locality 2312, and CIT locality 206. [Shallow-marine (transgressive) facies.]

438. At elevation of 1800 ft. on east side of stream bank

of Las Lajas Canyon, 7000 ft. (2134 m) N86°E of NE corner of section 29, T 3 N, R 17 W. Locality is equivalent to UCLA locality 2775. [Shallow-marine (transgressive) facies.]

439. At elevation of 1425 ft. on a ridge, 800 ft. (244 m) south and 1900 ft. (579 m) east of NW corner of section 31, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

440. At elevation of 1475 ft. on a ridge, 600 ft. (183 m) south and 1875 ft. (571 m) east of NW corner of section 31, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

441. At elevation of 1160 ft. on west side of Chivo Canyon near its mouth, 1890 ft. (576 m) south and 400 ft. (122 m) west of NE corner of section 31, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

442. At elevation of 1185 ft. on west side of Chivo Canyon near its mouth, 1600 ft. (488 m) south and 510 ft. (155 m) west of NE corner of section 31, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

443. At elevation of 1230 ft. on east side of Chivo Canyon near its mouth, 1370 ft. (418 m) south and 200 ft. (61 m) west of NE corner of section 31, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

444. At elevation of 1585 ft. on a small cliff on north side of a side canyon to Las Lajas Canyon, 2500 ft. (762 m) north

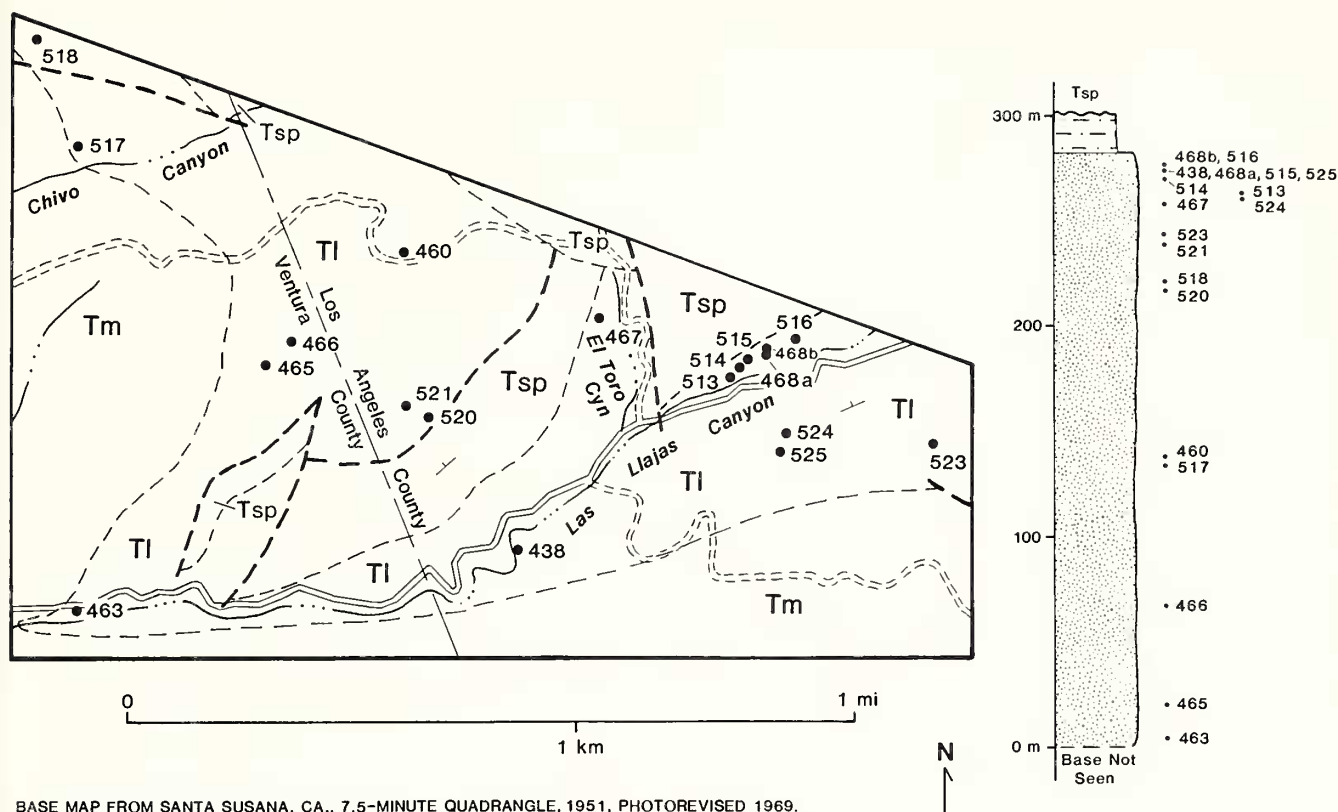


Figure 18. Geologic map showing CSUN fossil-collecting localities, Lajas Formation, upper Las Lajas Canyon area. Accompanying columnar section shows stratigraphic position of the fossil-collecting localities. See Figure 14 for explanation of symbols.

and 1375 ft. (419 m) east of SE corner of section 29, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

445. At elevation of 1485 ft. on a small cliff on west side of Las Lajas Canyon, 2820 ft. (859 m) north and 850 ft. (259 m) east of SE corner of section 29, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

446. At elevation of 1760 ft. in roadcut along ridge on west side of Las Lajas Canyon, 3460 ft. (1055 m) north and 200 ft. (61 m) east of SE corner of section 29, T 3 N, R 17 W. [Outer shelf and slope facies.]

447. At elevation of 1550 ft. on a small cliff on west side of Las Lajas Canyon, 2780 ft. (847 m) north and 550 ft. (168 m) east of SE corner of section 29, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

449. At elevation of 1700 ft. on a small cliff on west side of Las Lajas Canyon, 1825 ft. (556 m) north and 200 ft. (61 m) west of SE corner of section 29, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

450. At elevation of 1600 ft. on a small cliff on west side of Las Lajas Canyon, 2450 ft. (747 m) north and 125 ft. (38 m) east of SE corner of section 29, T 3 N, R 17 W. Locality

is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

451. At elevation of 1715 ft. on a small cliff on a hillside, 2100 ft. (640 m) north and 2100 ft. (640 m) west of SE corner of section 29, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

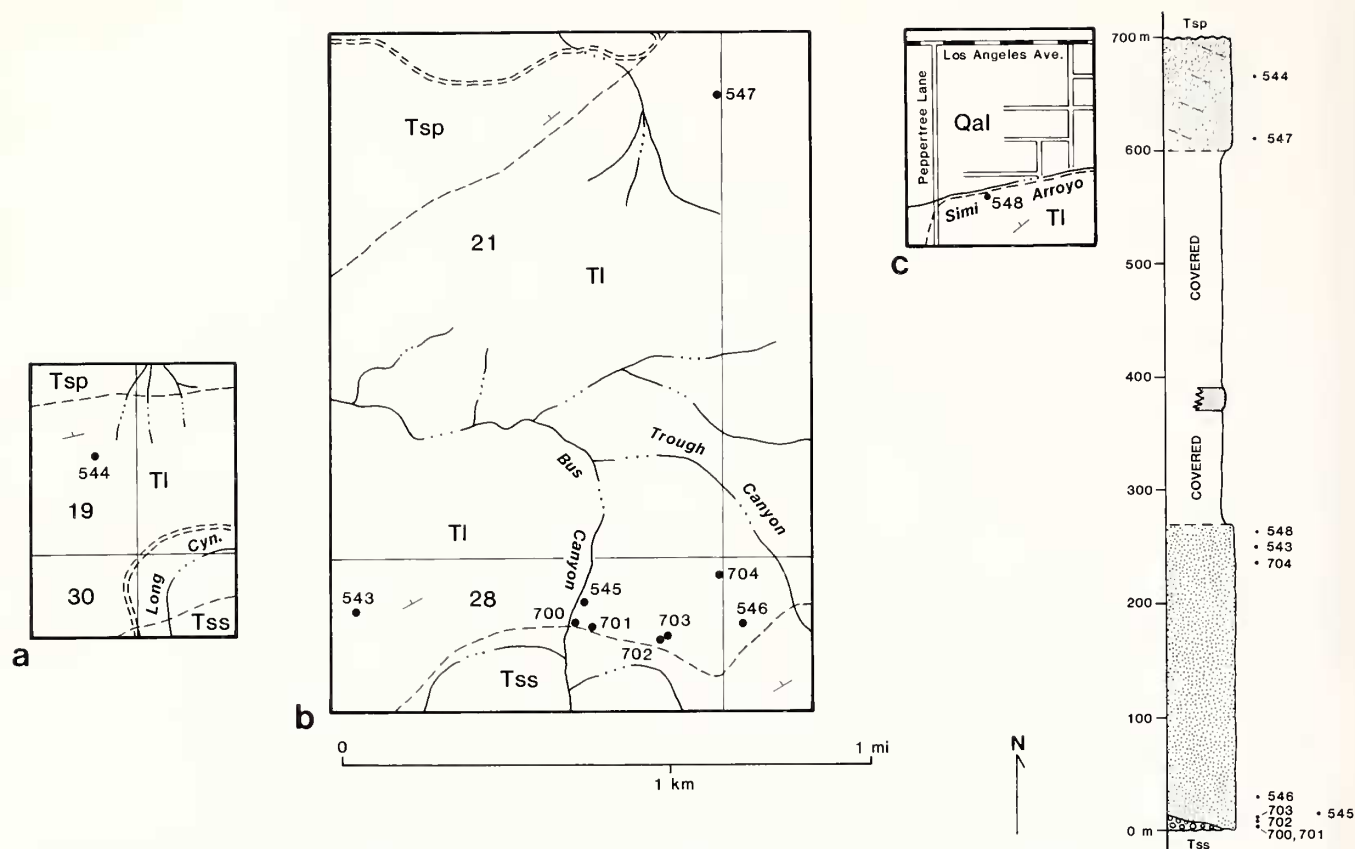
452. At elevation of 1285 ft. on west side of a small canyon branching north near mouth of Las Lajas Canyon, 1650 ft. (503 m) south and 550 ft. (168 m) east of NW corner of section 32, T 3 N, R 17 W. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

453. At elevation of 1275 ft. on west side of Chivo Canyon, 800 ft. (243 m) south and 700 ft. (213 m) west of NE corner of section 31, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

454. At elevation of 1310 ft. on west side of a small canyon branching north near mouth of Las Lajas Canyon, 1100 ft. (335 m) south and 810 ft. (247 m) east of NW corner of section 32, T 3 N, R 17 W. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

455. At elevation of 1475 ft. on east side of stream bank of Las Lajas Canyon, 2500 ft. (762 m) north and 625 ft. (191 m) east of SE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

457. At elevation of 1300 ft. on east side of Chivo Canyon,



BASE MAP FROM SANTA SUSANA (1951, PHOTOREVISED 1969) AND THOUSAND OAKS (1950, PHOTOREVISED 1967), CA., 7.5-MINUTE QUADRANGLES.

Figure 19. Geologic maps showing CSUN fossil-collecting localities, Lajas Formation, at various areas along the south side of Simi Valley. Accompanying columnar sections shows stratigraphic position of the fossil-collecting localities. See Figure 14 for explanation of symbols. **a.** Long Canyon area. **b.** Lower Bus Canyon area. **c.** Simi Arroyo-Peppertree Lane area.

900 ft. (274 m) north and 300 ft. (91 m) west of SE corner of section 30, T 3 N, R 17 W. Bed is the same one exposed at CSUN localities 469l and 511. [Shallow-marine (transgressive) facies.]

458. At elevation of 1300 ft. along south side of a ranch road that leads up south side of Chivo Canyon, 1550 ft. (472 m) north and 400 ft. (122 m) east of SW corner of section 29, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

459. At elevation of 1400 ft. on north side of Chivo Canyon, 1500 ft. (457 m) north and 400 ft. (122 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

460. At elevation of 2150 ft. on a hillside just north of a ranch road, 6700 ft. (2042 m) N67°E of NE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

462. At elevation of 1225 ft. on a hillside just north of an oilfield road, 2250 ft. (686 m) south and 2675 ft. (815 m) west of NE corner of section 36, T 3 N, R 18 W. Locality is near the Lajas-Sespe contact. [Shallow-marine (regressive) facies.]

463. At elevation of 1650 ft. in streambed, Las Lajas Canyon, 3725 ft. (1135 m) N89°E of SE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

465. At elevation of 2100 ft. on south side of a hill, 5480 ft. (1670 m) N70°E of NE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

466. At elevation of 2150 ft. along east side of a hill, 5700 ft. (1738 m) N69°E of NE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

467. At elevation of 1900 ft. on west side of stream bank of El Toro Canyon, 7900 ft. (2408 m) N69°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

468a. At elevation of 1975 ft. on north side of stream bank of Las Lajas Canyon, 6675 ft. (2034 m) N69°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. Bed is the same one exposed at CSUN locality 515. [Shallow-marine (transgressive) facies.]

468b. Bed 10 ft. (3 m) stratigraphically above locality 468a.

Bed is the same one exposed at CSUN locality 516. [Shallow-marine (transgressive) facies.]

469a. At elevation of 1400 ft. on north side of a small canyon branching west from Chivo Canyon, 100 ft. (31 m) north and 1650 ft. (503 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is at the type section of the Lajas Formation, 144 ft. (44 m) above the base of the formation. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

469b. Bed 26 ft. (8 m) stratigraphically above locality 469a, on a traverse bearing N10°W from locality 469a. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

469c. Bed 13 ft. (4 m) stratigraphically above locality 469b, on a traverse bearing N10°W from locality 469b. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

469d. Bed 13 ft. (4 m) stratigraphically above locality 469c, on a traverse bearing N10°W from locality 469c. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

469e. Bed 20 ft. (6 m) stratigraphically above locality 469d, on a traverse bearing N10°W from locality 469d. [Shallow-marine (transgressive) facies.]

469f. Bed 6.5 ft. (2 m) stratigraphically above locality 469e, on a traverse bearing N10°W from locality 469e. [Shallow-marine (transgressive) facies.]

469g. Bed 6.5 ft. (2 m) stratigraphically above locality 469f, on a traverse bearing N10°W from locality 469f. [Shallow-marine (transgressive) facies.]

469h. Bed 16 ft. (5 m) stratigraphically above locality 469g, on a traverse bearing N10°W from locality 469g. [Shallow-marine (transgressive) facies.]

469i. Bed 9 ft. (3 m) stratigraphically above locality 469h, on a traverse bearing N10°W from locality 469h. [Shallow-marine (transgressive) facies.]

469j. Bed 75 ft. (19 m) stratigraphically above locality 469g, on a traverse bearing N10°W from locality 469g. [Shallow-marine (transgressive) facies.]

469k. Bed 20 ft. (6 m) stratigraphically above locality 469j, on a traverse bearing N10°W from locality 469j. [Shallow-marine (transgressive) facies.]

469l. Bed 13 ft. (4 m) stratigraphically above locality 469k, on a traverse bearing N55°W from locality 469k. Bed is the same one exposed at CSUN localities 457 and 511. [Shallow-marine (transgressive) facies.]

470a. At elevation of 1550 ft. on south side of an amphitheater on west side of Chivo Canyon, 500 ft. (152 m) north and 2100 ft. (640 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is at the type section of the Lajas Formation, 266 ft. (81 m) stratigraphically above locality 469l. [Shallow-marine (transgressive) facies.]

470b. Bed 62 ft. (19 m) stratigraphically above locality 470a, on a traverse bearing N60°W from locality 470a. [Shallow-marine (transgressive) facies.]

470c. Bed 33 ft. (10 m) stratigraphically above locality 470b, on a traverse bearing N60°W from locality 470b. [Shallow-marine (transgressive) facies.]

471a. At elevation of 1450 ft. on west side of an amphitheater on west side of Chivo Canyon, 600 ft. (183 m) north and 2125 ft. (655 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is at the type section of the Lajas Formation, 125 ft. (38 m) stratigraphically above locality 470c. [Shallow-marine (transgressive) facies.]

471b. Bed 144 ft. (44 m) stratigraphically above locality 471a, on a traverse bearing N27°W from locality 471a. [Shallow-marine (transgressive) facies.]

471c. Bed 20 ft. (6 m) stratigraphically above locality 471b, on a traverse bearing N27°W from locality 471b. [Shallow-marine (transgressive) facies.]

471d. Bed 39 ft. (12 m) stratigraphically above locality 471c, on a traverse bearing N27°W from locality 471c. [Shallow-marine (transgressive) facies.]

471e. Bed 79 ft. (24 m) stratigraphically above locality 471d, on a traverse bearing N27°W from locality 471d. [Shallow-marine (transgressive) facies.]

472. At elevation of 1600 ft. on a ridge, 1000 ft. (305 m) north and 2300 ft. (701 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is at the type section of the Lajas Formation and in the "Stewart bed," 46 ft. (14 m) stratigraphically above locality 471e. [Shallow-marine (transgressive) facies.]

473. At elevation of 1650 ft. on a ridge, 1050 ft. (320 m) north and 2300 ft. (701 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is at the type section of the Lajas Formation, 46 ft. (14 m) stratigraphically above locality 472. The bed that this locality occurs in probably represents a shallow-marine (transgressive) facies bed that interfingers with the outer shelf and slope facies.

475. At elevation of 1625 ft. on a ridge, 1300 ft. (396 m) north and 3100 ft. (945 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is at the type section of the Lajas Formation, approximately 446 ft. (136 m) stratigraphically above locality 473. [Shallow-marine (regressive) facies.]

476. Bed 13 ft. (4 m) stratigraphically above locality 475, on a traverse bearing N15°W from locality 475. [Shallow-marine (regressive) facies.]

477. At elevation of 1625 ft. on a ridge, 1200 ft. (366 m) north and 1700 ft. (518 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

478. At elevation of 1735 ft. just below a saddle along a ridge, 680 ft. (270 m) north and 2670 ft. (814 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

479. At elevation of 1775 ft. just below a saddle along a ridge, 650 ft. (198 m) north and 2700 ft. (823 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

480. At elevation of 1400 ft. near a canyon bottom, 200 ft. (61 m) north and 3400 ft. (1036 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

481. At elevation of 1500 ft. on a ridge, 325 ft. (99 m) south and 1800 ft. (549 m) east of NE corner of section 31, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

482. At elevation of 1435 ft. in a roadcut, 1100 ft. (335 m) south and 300 ft. (91 m) west of NE corner of section 36, T 3 N, R 18 W. [Outer shelf and slope facies.]

483. At elevation of 1525 ft. on west side of a ridge, 925 ft. (282 m) south and 175 ft. (53 m) west of NE corner of section 36, T 3 N, R 18 W. [Outer shelf and slope facies.]

484. At elevation of 2340 ft. on a ridge, 6000 ft. (1829 m) N68°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

485. Bed 135 ft. (41 m) stratigraphically below locality 484, on a traverse bearing S23°E from locality 484. [Shallow-marine (transgressive) facies.]

486. Bed 69 ft. (21 m) stratigraphically below locality 485, on a traverse bearing S23°E from locality 485. [Shallow-marine (transgressive) facies.]

487. Bed 174 ft. (53 m) stratigraphically below locality 486, on a traverse bearing S23°E from locality 486. [Shallow-marine (transgressive) facies.]

488. At elevation of 2175 ft. on a ridge, 5650 ft. (1722 m) N64°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

489. At elevation of 1250 ft. on east side of a canyon, 125 ft. (38 m) south of NW corner of section 31, T 3 N, R 17 W. [Shallow-marine (regressive) facies.]

490. At elevation of 1900 ft. in a saddle along a ridge, 600 ft. (183 m) north and 800 ft. (244 m) east of SE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

491. At elevation of 1840 ft. on east side of a small canyon, 500 ft. (145 m) north and 1100 ft. (320 m) east of SE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

492. At elevation of 2230 ft. in a saddle along a ridge, 1700 ft. (518 m) north and 3225 ft. (983 m) east of SE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

493. At elevation of 2225 ft. in saddle along a ridge, 1825 ft. (556 m) north and 3450 ft. (1052 m) east of SE corner of section 29, T 3 N, R 17 W. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

494. At elevation of 2050 ft. on a small cliff, 5350 ft. (1630 m) N62°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

495. At elevation of 2050 ft. on a small cliff, 4725 ft. (1440 m) N60°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

496. At elevation of 2050 ft. on a hillside, 4100 ft. (1250 m) N59°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is

in the Oat Mountain quadrangle. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

497. At elevation of 2185 ft. on south side of ridge, 3685 ft. (1123 m) N58°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. Locality is in the "Stewart bed." [Shallow-marine (transgressive) facies.]

498. At elevation of 1850 ft. on west side of stream bank of Devil Canyon, 1550 ft. (472 m) south and 600 ft. (183 m) west of NE corner of section 26, T 3 N, R 17 W of the USGS 7.5-minute topographic quadrangle of Oat Mountain, California (1952), photorevised 1969. [Shallow-marine (transgressive) facies.]

499. At elevation of 1850 ft. on west side of stream bank of Devil Canyon, 1400 ft. (427 m) south and 630 ft. (192 m) west of NE corner of section 26, T 3 N, R 17 W of the USGS 7.5-minute topographic quadrangle of Oat Mountain, California (1952), photorevised 1969. [Shallow-marine (transgressive) facies.]

500. At elevation of 1875 ft. on east side of stream bank of Devil Canyon, 800 ft. (244 m) south and 675 ft. (206 m) west of NE corner of section 26, T 3 N, R 17 W of the USGS 7.5-minute topographic quadrangle of Oat Mountain, California (1952), photorevised 1969. [Shallow-marine (transgressive) facies.]

501. At elevation of 1500 ft. on east side of a small canyon branching northwest of Las Lajas Canyon, 1400 ft. (427 m) north and 1400 ft. (427 m) west of SE corner of section 29, T 3 N, R 17 W. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

502. At elevation of 2150 ft. on a ridge, 5700 ft. (1737 m) N70°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

503. At elevation of 2160 ft. on a ridge, 5725 ft. (1745 m) N69°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

504. At elevation of 2225 ft. on a ridge, 5750 ft. (1753 m) N71°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

505. Bed 98 ft. (30 m) stratigraphically above locality 504, on a traverse bearing N23°W from locality 504. [Shallow-marine (transgressive) facies.]

506. At elevation of 2280 ft. on a ridge, 5600 ft. (1706 m) N65°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

507. Bed 33 ft. (10 m) stratigraphically above locality 506, on a traverse bearing N6°E from locality 506. [Shallow-marine (transgressive) facies.]

508. Bed 6.5 ft. (2 m) stratigraphically above locality 507,

on a traverse bearing N6°E from locality 507. [Shallow-marine (transgressive) facies.]

509. Bed 49 ft. (15 m) stratigraphically above locality 508, on a traverse bearing N6°E from locality 508. [Shallow-marine (transgressive) facies.]

510. Bed 108 ft. (33 m) stratigraphically above locality 509, on a traverse bearing N6°E from locality 509. [Shallow-marine (transgressive) facies.]

511. At elevation of 1225 ft. on north side of Chivo Canyon near a major fork in Chivo Canyon, 800 ft. (244 m) north and 800 ft. (244 m) west of SE corner of section 30, T 3 N, R 17 W. Bed is the same one exposed at CSUN localities 457 and 469l. [Shallow-marine (transgressive) facies.]

512a. At elevation of 1275 ft. on east side of a small canyon branching north of Chivo Canyon, 2275 ft. (693 m) south and 525 ft. (160 m) east of NW corner of section 29, T 3 N, R 17 W. [Shallow-marine (regressive) facies.]

512b. Bed 20 ft. (6 m) stratigraphically above locality 512a, on a traverse bearing N35°W from locality 512a. [Shallow-marine (regressive) facies.]

512c. Bed 16 ft. (5 m) stratigraphically above locality 512b, on a traverse bearing N35°W from locality 512b. [Shallow-marine (regressive) facies.]

512d. Bed 30 ft. (9 m) stratigraphically above locality 512b, on a traverse bearing N35°W from locality 512b. [Shallow-marine (regressive) facies.]

513. At elevation of 1870 ft. (570 m) in the streambed of Las Lajas Canyon, 6825 ft. (2080 m) N71°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

514. At elevation of 1875 ft. on north side of stream bank of Las Lajas Canyon, 6800 ft. (2073 m) N71°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

515. At elevation of 1925 ft. (587 m) on the north side of stream bank of Las Lajas Canyon, 6750 ft. (2057 m) N69°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. Bed is the same one exposed at CSUN locality 468a. [Shallow-marine (transgressive) facies.]

516. At elevation of 1975 ft. (602 m) on north side of stream bank of Las Lajas Canyon, 6500 ft. (1981 m) N67°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. Bed is the same one exposed at CSUN locality 468b. [Shallow-marine (transgressive) facies.]

517. At elevation of 1950 ft. in a small canyon bottom, between the letters "n" and "y" in the word "Canyon," 5100 ft. (1555 m) N47°E of NE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

518. At elevation of 2125 ft. on a small ridge, 5475 ft. (1669 m) N40°E of NE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

520. At elevation of 2070 ft., 6500 ft. (1981 m) N78°E of NE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

521. At elevation of 2115 ft. on a ridge, 6360 ft. (1938 m) N88°E of NE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

522. Bed 131 ft. (40 m) stratigraphically above CSUN locality 371, on a traverse bearing S14°W from locality 371. [Shallow-marine (transgressive) facies.]

523. At elevation of 2100 ft. on west side of a canyon branching south of Las Lajas Canyon, 5275 ft. (1608 m) N70°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

524. At elevation of 2035 ft. on ridge along south side of Las Lajas Canyon, 6375 ft. (1943 m) N72°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

525. At elevation of 2050 ft. on a hillside, 6325 ft. (1928 m) N74°W of SE corner of section 23, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

526. At elevation of 2055 ft. on a ridge, 2290 ft. (698 m) N67°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

527a. At elevation of 2075 ft. on a ridge, 2325 ft. (709 m) N65°W of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

527b. Bed 13 ft. (4 m) stratigraphically above locality 527a, on a traverse bearing due north of locality 527a. [Shallow-marine (transgressive) facies.]

528. At elevation of 2185 ft. on a ridge, 1400 ft. (427 m) north and 2250 ft. (686 m) west of SE corner of section 26, T 3 N, R 17 W. Locality is in the Santa Susana quadrangle, but the section corner is in the Oat Mountain quadrangle. [Shallow-marine (transgressive) facies.]

529a. At elevation of 1400 ft. on east side of stream bank of Las Lajas Canyon, 1300 ft. (396 m) north and 350 ft. (107 m) east of SE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

529b. Bed 26.5 ft. (7 m) stratigraphically above locality 529a, on a traverse bearing N27°E of locality 529a. [Shallow-marine (transgressive) facies.]

537. At elevation of 1500 ft. on west side of an amphitheater on west side of Chivo Canyon, 790 ft. (241 m) north and 2250 ft. (686 m) west of SE corner of section 30, T 3 N, R 17 W. Locality is at the type section of the Lajas Formation. [Shallow-marine (transgressive) facies.]

538. At elevation of 1500 ft. on a ridge on west side of Las Lajas Canyon, 1500 ft. (457 m) north and 350 ft. (107 m) west of SE corner of section 29, T 3 N, R 17 W. [Shallow-marine (transgressive) facies.]

539. Bed 6 ft. (1.8 m) stratigraphically above locality 538,

on a traverse bearing N5°E of locality 538. [Shallow-marine (transgressive) facies.]

540. Bed 38 ft. (11.5 m) stratigraphically below CSUN locality 486, on a traverse bearing S28°E from locality 486. [Shallow-marine (transgressive) facies.]

541. At elevation of 1325 ft. on north bank of stream bank of Chivo Canyon, 2800 ft. (853 m) north and 1175 ft. (358 m) east of SE corner of section 29, T 3 N, R 17 W. [Outer shelf and slope channel facies.]

542. At elevation of 1315 ft. on ridge near mouth of Las Lajas Canyon, 2200 ft. (671 m) north and 800 ft. (244 m) east of SW corner of section 32, T 3 N, R 17 W. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

543. At elevation of 1460 ft. on divide between Bus and Montgomery Canyons, 600 ft. (183 m) south and 1500 ft. (457 m) east of NW corner of section 28, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. [Shallow-marine (transgressive) facies.]

544. At elevation of 1230 ft. on a small ridge, 1025 ft. (312 m) north and 415 ft. (127 m) west of SE corner of section 19, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. [Shallow-marine (regressive) facies.]

545. At elevation of 1120 ft. on east side of Bus Canyon, 580 ft. (177 m) south and 1410 ft. (430 m) west of NE corner of section 28, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

546. At elevation of 1500 ft. on east side of divide between Bus and Trough Canyons, 700 ft. (213 m) south and 200 ft. (61 m) east of NW corner of section 27, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. [Shallow-marine (transgressive) facies.]

547. At elevation of 1010 ft. on east side of a roadcut, 650 ft. (198 m) south of NE corner of section 21, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. [Shallow-marine (regressive) facies.]

548. At elevation of 947 ft. on south side of Simi Arroyo just above the streambed, 1100 ft. (335 m) north and 1750 ft. (553 m) west of SE corner of section 12, T 2 N, R 18 W. Locality is equivalent to UCLA locality 5837. [Shallow-marine (transgressive) facies.]

700. At elevation of 1100 ft. along east side of road in Bus Canyon, 750 ft. (229 m) south and 1500 ft. (457 m) west of NE corner of section 28, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

701. At elevation of 1160 ft. along east side of Bus Canyon, 800 ft. (244 m) south and 1400 ft. (427 m) west of NE corner of section 28, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

702. At elevation of 1420 ft. along a ridge, 900 ft. (274 m) south and 680 ft. (207 m) west of NE corner of section 28, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. Locality is equivalent to UCMP locality 7193 and UCLA locality 7070. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

703. At elevation of 1430 ft. along a ridge, 780 ft. (238 m) south and 580 ft. (177 m) west of NE corner of section 28, T 2 N, R 18 W of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. Locality is a few meters stratigraphically above locality 702. [Lowermost part of shallow-marine (transgressive) facies.]

704. At elevation of 1320 ft. along divide between Bus and Trough Canyons, 180 ft. (55 m) south and 90 ft. (27 m) west of NE corner of section 28 of the USGS 7.5-minute topographic quadrangle of Thousand Oaks, California (1950), photorevised 1967. [Shallow-marine (transgressive) facies.]

705. At elevation of 1240 ft. along a dip-slope just south of the mouth of Las Lajas Canyon, 2450 ft. (747 m) north and 450 ft. (137 m) east of SW corner of section 32, T 3 N, R 17 W. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

706. At elevation of 1250 ft. along a small ridge on east side of Chivo Canyon where it bends sharply to the northeast, 700 ft. (213 m) north and 590 ft. (180 m) west of SE corner of section 30, T 3 N, R 17 W. [Interfingering coastal alluvial-fan facies and shallow-marine (transgressive) facies.]

CAS LOCALITIES

25. On east bank of Little River at its confluence with Umpqua River, near center of section 19, T 26 S, R 3 W. Roseburg quadrangle, Douglas County, Oregon.

364. Exact location unknown. Aliso Creek (now known as Devil Canyon), section 25, T 3 N, R 17 W, near Chatsworth, California, Los Angeles County.

372. Exact location unknown. Aliso Canyon (now known as Devil Canyon), section 23, T 3 N, R 17 W, near Chatsworth, California, Los Angeles County.

393. Devil Canyon, SE ¼ of the NW ¼ of section 26, T 3 N, R 17 W, Santa Susana quadrangle, California.

711. East side of Grapevine Creek near point where it enters valley floor, Tejon quadrangle, Kern County, California.

792. West side of Tecuya Creek, about 1 mile south of where stream flows out on valley floor, Tejon quadrangle, Kern County, California.

HERMAN SCHYMICZEK LOCALITY

HS-A-11(4). Bed 92 ft. (28 m) stratigraphically above CSUN locality 4691, on a traverse bearing due north from locality 4691.

LACMIP LOCALITY

461-B. On the northern slope of a small canyon intersecting Las Lajas Canyon from the east. It is 200 ft. (61 m) from

the top of the Llajas Formation, Las Llajas Canyon, Santa Susana Mountains, Ventura County, California.

SU LOCALITY

2696. Chivo Canyon, 5 km N20°E of Bench Mark 961 at Santa Susana, Santa Susana quadrangle, Ventura County, California.

UCMP LOCALITIES

337. About 5 km south of Martinez, on the east side of the road to Walnut Creek, Concord quadrangle, Contra Costa County, California.

452. On road in Grapevine Creek, SW ¼ of the SE ¼ of section 20, T 10 N, R 19 W, Tejon quadrangle, Kern County, California.

672. South portion of crest of Parson's Peak, SE ¼ of the NW ¼ of section 24, T 18 S, R 14 E, Coalinga quadrangle, Fresno County, California.

1427. SW ¼ of section 11, NE of Wall Point, south side of Mount Diablo, California.

1817. Opposite the place where Urruttia Canyon enters Salt Creek, 100 ft. (30 m) up fourth small draw from west end of ridge, SW ¼ of the NW ¼ of section 15, T 18 S, R 14 E, Coalinga quadrangle, Fresno County, California.

1853. Marysville Buttes, N ½ of section 28, T 16 N, R 1 E, Marysville Buttes quadrangle, Sutter County, California.

2226. Longitude 117°14'W, latitude 33°50'N, SE of Soledad Mountain, north of Ladrillo Station, Southern Pacific Railroad, Rose Canyon, La Jolla quadrangle, San Diego County, California.

2287. West side of Domengine Canyon, SW corner of the SW ¼ of the SE ¼ of section 29, T 18 S, R 15 E, Fresno County, California.

2295. Longitude 120.1°W, latitude 36.1°N, near Domengine Ranch, Fresno County, California.

3296. Exact location unknown. Aliso Canyon (now known as Devil Canyon), SE ¼ of the SE ¼ of section 23, T 3 N, R 17 W, Santa Susana quadrangle, Ventura County, California.

3304. Exact location unknown. Aliso Canyon (now known as Devil Canyon, section 36, T 3 N, R 17 W, Santa Susana quadrangle, Los Angeles County, California.

3310. Exact location unknown. Probably Simi Hills, Santa Susana quadrangle, California.

3976. Seven-eighths of a mile (1.4 km) north of Ladrillo Station, Southern Pacific Railroad, in first canyon east of Rose Canyon, elevation 259 ft., La Jolla quadrangle, San Diego County, California.

3981. At 15 m above high-tide level in small gully 0.4 km south of mouth of Soledad Valley, La Jolla quadrangle, San Diego County, California.

3989. 0.2 mi. (0.3 km) north of the top of the "y" of "Tecolote Valley," on the east side of the valley, elevation 100 ft., La Jolla quadrangle, San Diego County, California.

3990. On the east side of canyon in bottom of Rose Creek, 0.3 mi. (0.5 km) east of "t" of "Soledad Mountain," La Jolla quadrangle, San Diego County, California.

3993. In bottom of Rose Creek where creek makes a strong bend to west, 0.2 mi. (0.3 km) south of Bench Mark 176, 2

mi. (3.2 km) east of La Jolla, La Jolla quadrangle, San Diego County, California.

4169. About 500 ft. (152 m) east of ranch house in Big Tar Canyon on east line of section 18, near point where road crosses creek, Garza Peak quadrangle, Kings County, California.

4170. On west side of Big Tar Canyon, where it crosses the Eocene section, Garza Peak quadrangle, Kings County, California.

4175. No locality data available. Probably Domengine Ranch area, north of Coalinga, Domengine Ranch quadrangle, Fresno County, California.

5062. In sea cliff south of mouth of Soledad Valley, due west of midpoint between "P" and "u" of Pueblo," La Jolla quadrangle, San Diego County, California.

5069. 0.4 inches SSE of the "a" in "Morena" in a branch canyon of Tecolote Valley to the north, elevation 150 ft., La Jolla quadrangle, San Diego County, California.

5080. North side of Soledad Valley, at McGonigle Canyon, NE ¼ of section 36, T 14 S, R 4 W, La Jolla quadrangle, San Diego County, California.

5085. 2.62 inches north of the top of the "S" of "Soledad Mountain," on the north side of the creek, on a small ridge formed by the creek and sea cliff, elevation 75 ft., La Jolla quadrangle, San Diego County, California.

5089. 300 ft. (91 m) north of the Scripps Institution pier, in the conglomerate above the mudstone. In the sea cliff, elevation 10 ft., La Jolla quadrangle, San Diego County, California.

7000. Exact location unknown. Las Llajas Canyon, in first canyon on north side of road, Santa Susana quadrangle, California.

7002. At elevation of 1750 ft., in road near top of last western spur which extends northward out of Las Llajas Canyon. In shales striking north just south of east-west fault which is made prominent by the Meganos Conglomerate which parallels it on the north side, Santa Susana quadrangle, Ventura County.

7003. At elevation of 1760 ft. in sandstone exposed in deep washout on south side of second large canyon which enters Llajas Canyon from the east. Washout is about 100 yards east of mouth of canyon. Fossils are found in ledge on west side of washout and near top. Sandstone here dips with slope of canyon side and from west wall of east-west fault which crosses Llajas Canyon south of this locality, Santa Susana quadrangle, Ventura County.

7004. About 300 ft. (91 m) east of locality 7003 in next small canyon which enters Llajas Canyon from the east just south of the most northerly extension of the 1500-ft. contour, Santa Susana quadrangle, Ventura County. Locality is equivalent to CSUN locality 374.

7005. No locality data available. Probably Las Llajas Canyon area, Santa Susana quadrangle, California.

7015. About 5500 ft. (1676 m) S69°E of Bench Mark at Santa Susana, Santa Susana quadrangle, Ventura County.

7182. Boulder from second draw on east side of Live Oak Canyon, Tejon Ranch, Kern County, California.

7193. About 600 ft. (183 m) east of and apparently slightly stratigraphically beneath locality 7194, which is along the

top of a 1400-ft. ridge extending NW from third main ridge west of Runkle's Ranch on the ridge on which there is an abandoned well and road leading up to it, Simi Valley, California. Locality is equivalent to CSUN locality 702 and UCLA locality 7070.

7195. In the creek bed about 60 ft. (18 m) north of the second falls or 300 ft. (91 m) north of the mouth of the first small draw which enters Las Lajas Canyon west of the point where the Meganos Conglomerate crosses the road, Santa Susana quadrangle, Ventura County, California.

7200. No locality data available. Probably Live Oak Canyon area, Tejon Ranch, Kern County, California.

A-661. On east bank of Little River between the highway bridge and the first bend of the stream east of the junction with the North Umpqua River, center of section 19, T 26 S, R 3 W, Douglas County, Oregon.

A-819. Lowest reef bed on side of hill just east of and above first saddle south of Big Tar Canyon, Garza Peak quadrangle, Kings County, California.

A-993. Second draw past Marrland Canyon (now known as Las Lajas Canyon) at second small falls up draw approximately 600 ft. (183 m), Santa Susana quadrangle, Ventura County, California.

A-994. About 225 to 300 ft. (69 to 91 m) down the canyon from locality A-993 on west side of canyon about 60 ft. (18 m) from streambed, Santa Susana quadrangle, Ventura County, California.

A-1003. Exact location unknown. Pine Canyon, Mount Diablo, Contra Costa County, California.

A-1027. Valdes Ranch, on branch of Silver Creek, Vallecitos, center of east part of SW $\frac{1}{4}$ of section 4, T 16 S, R 12 E. Approximately where $120^{\circ}40'$ parallel crosses most northerly intermittent stream indicated on section 4, Panoche quadrangle, Fresno County, California.

A-1219. Base of Domengine Formation on west side, near top, of long ridge extending NW of 2126-ft. hill on line between sections 9 and 16, T 19 S, R 15 E, Domengine Ranch quadrangle, California.

A-1280. Near center of north edge of section 20, on hill immediately south of point where the Big Tar-McLure Valley road crosses saddle at head of stream running into McLure Valley, 45 ft. (14 m) below uppermost fossiliferous layer, Garza Peak quadrangle, Kings County, California.

A-3042. On ridge in blue clay shale member above conglomerate member at base of Lajas Formation, center of SE $\frac{1}{4}$ of the SE $\frac{1}{4}$ of section 10, T 3 N, R 17 W, Santa Susana quadrangle, Los Angeles County, California.

UCLA LOCALITY

6616. West end of ridge south of Las Lajas Canyon, 2525 ft. (770 m) north and 575 ft. (175 m) east of SW corner of section 32, T 3 N, R 17 W, Santa Susana quadrangle, Ventura County, California.

UCR LOCALITY

4865. In a roadcut on the southwest side of California State Highway 78, 5.2 km SE of Vista and 4.8 km NW of San

Marcos, at longitude $117^{\circ}12'39''$ W, latitude $33^{\circ}09'47''$ N, in northern San Diego County, California.

UO LOCALITY

144. About 2.5 mi. (4 km) up Fall Creek from Little River on Mathews farm in NE $\frac{1}{4}$ of section 6, T 27 S, R 3 W, Douglas County, Oregon.

USGS LOCALITIES

4617. On SW flank of Reef Ridge, north of McLure Valley, $2\frac{1}{4}$ mi. (3.6 km) SSE of El Cerrito oil well, in section 27, T 23 S, R 17 E, Cholame quadrangle, Kings County, California.

4619. North of Coalinga, 15 mi. (24 km) SW of Domengine's Ranch, T 18 S, R 15 E, Coalinga quadrangle, Fresno County, California.

UW LOCALITIES

329. On north bank of the Cowlitz River at bend 1.5 to 2.5 km east of Vader, section 28, T 1 N, R 2 W, Lewis County, Washington.

358. Joice Station, $\frac{1}{4}$ mi. (0.4 km) east of Tongue Point Railroad, Port Crescent, section 22, T 31 N, R 8 W, Clallam County, Washington.

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